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TECHNOLOGY REVIEW

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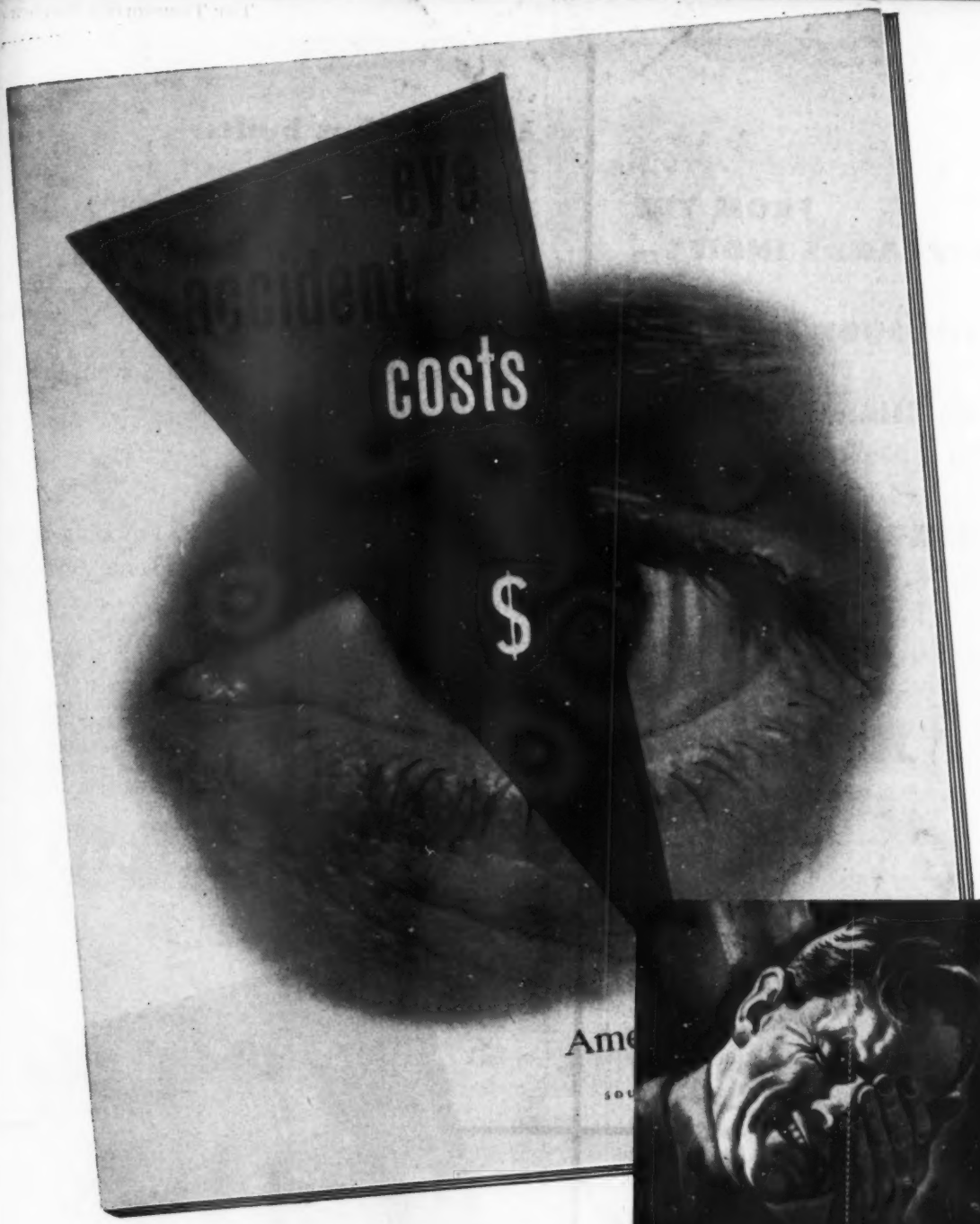

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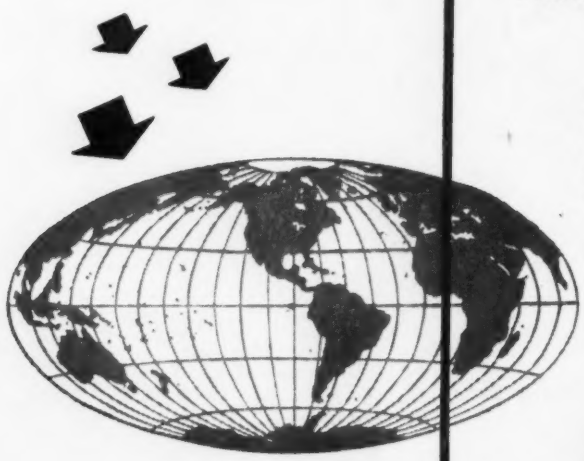

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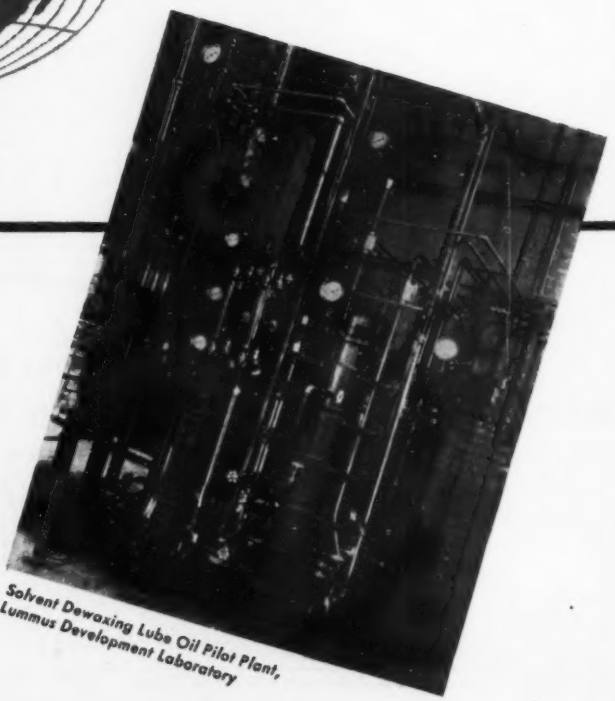

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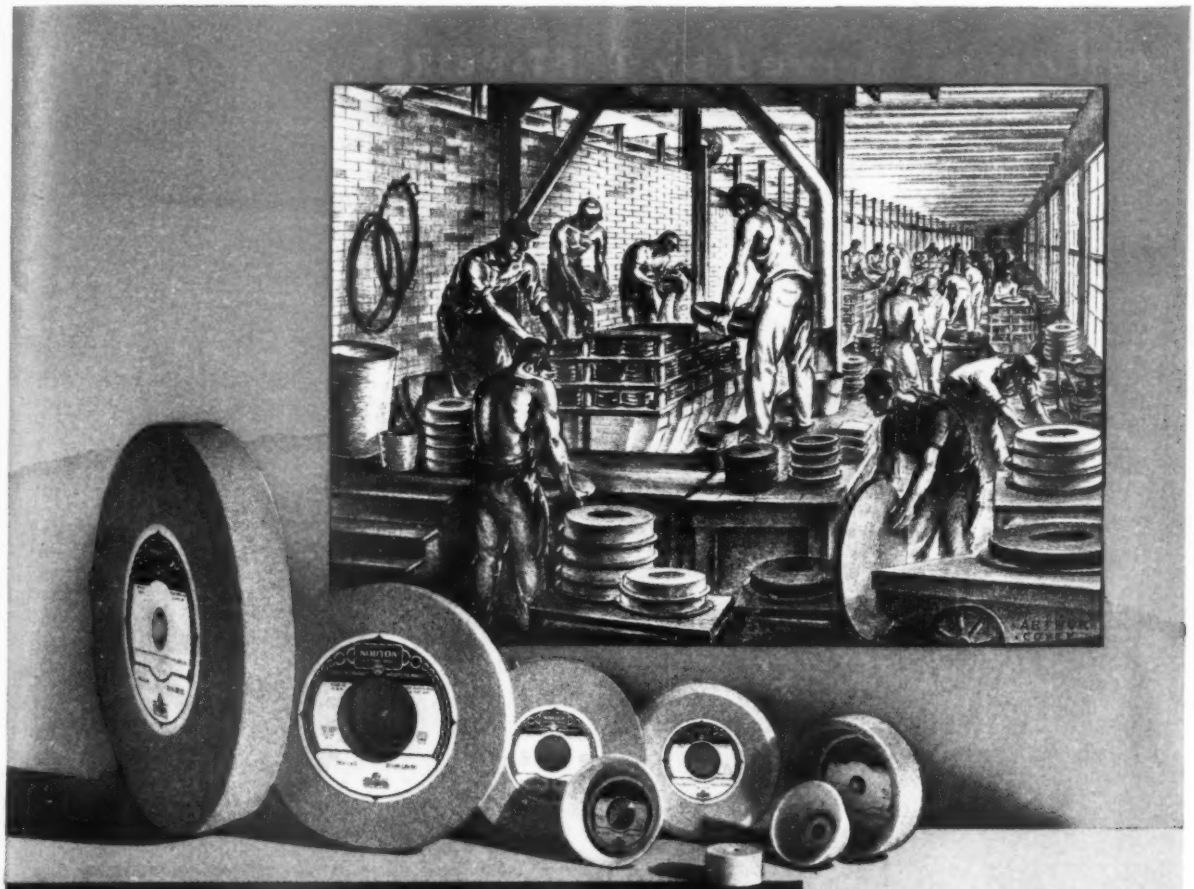

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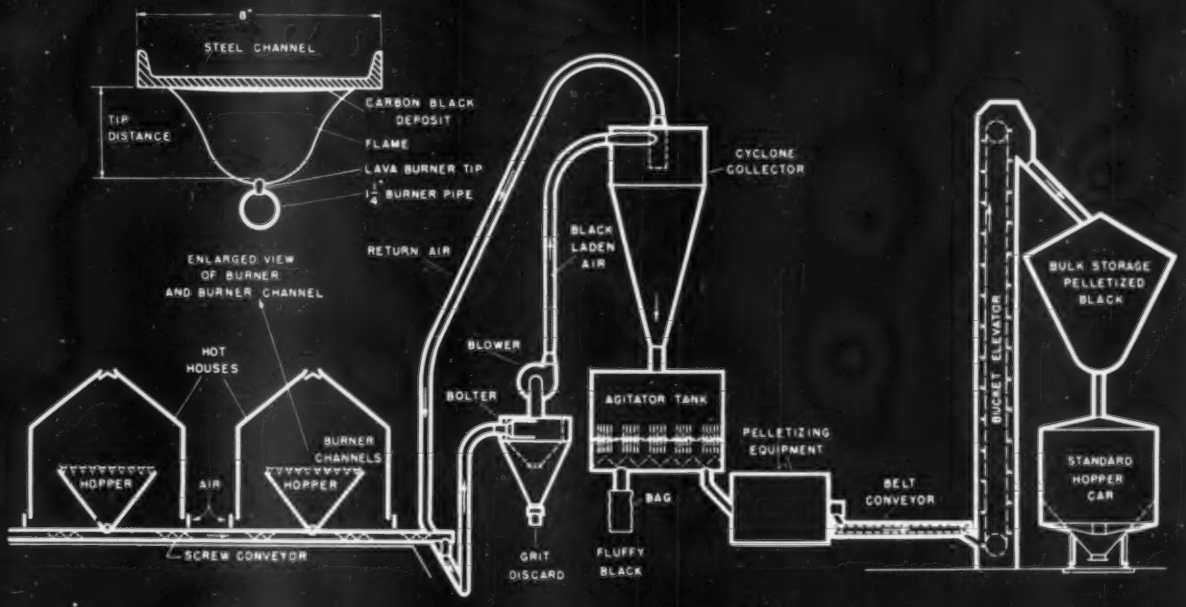

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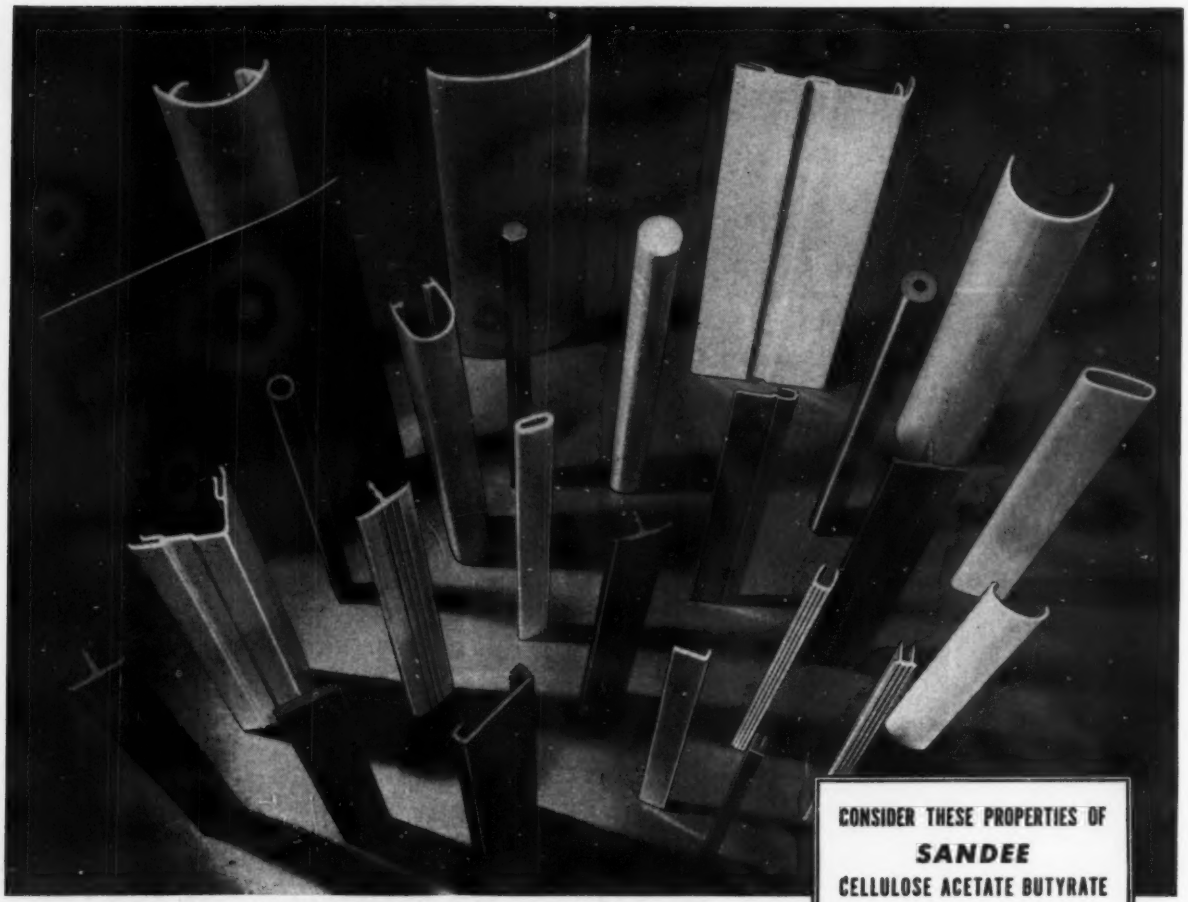

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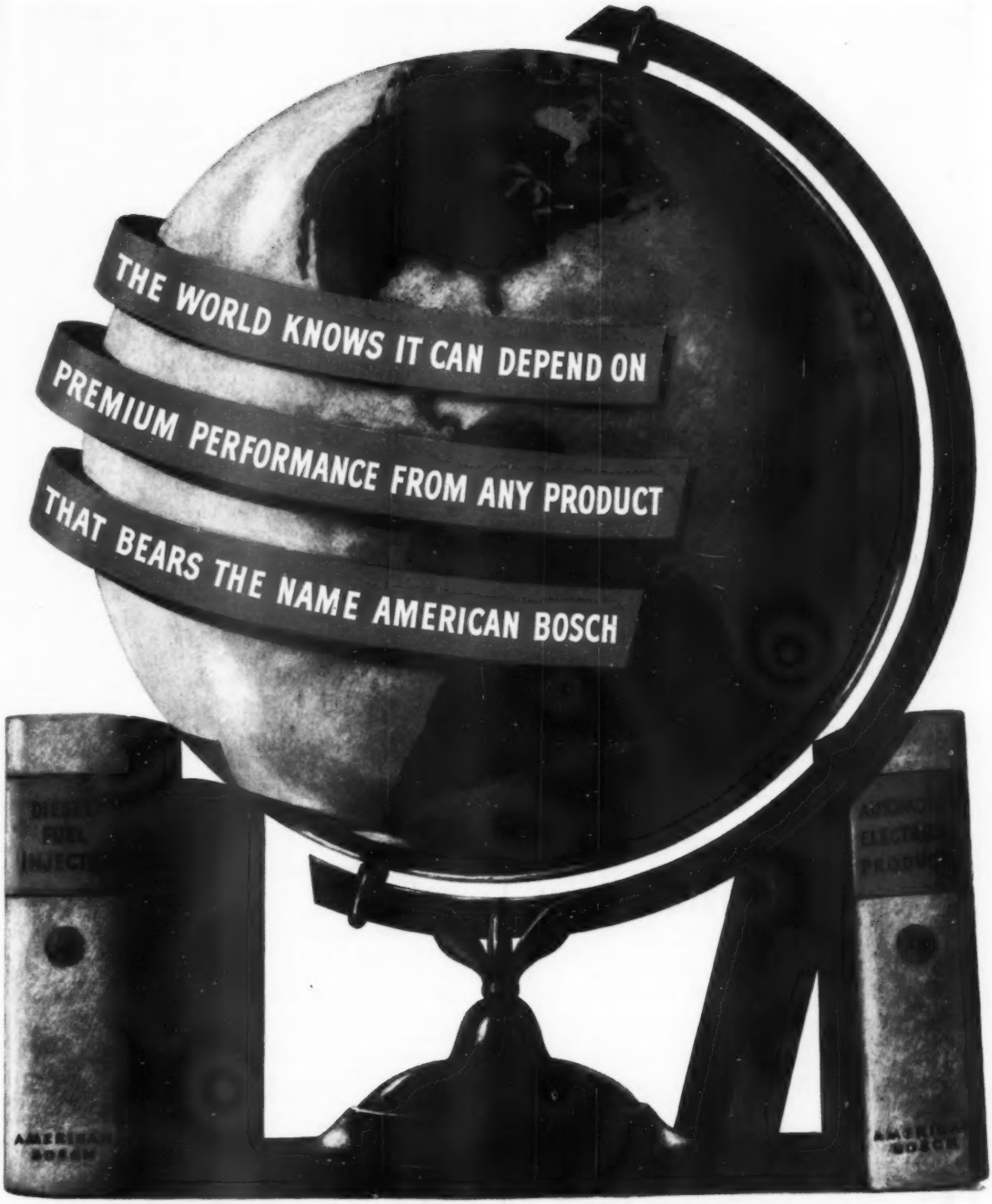

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THE TABULAR VIEW

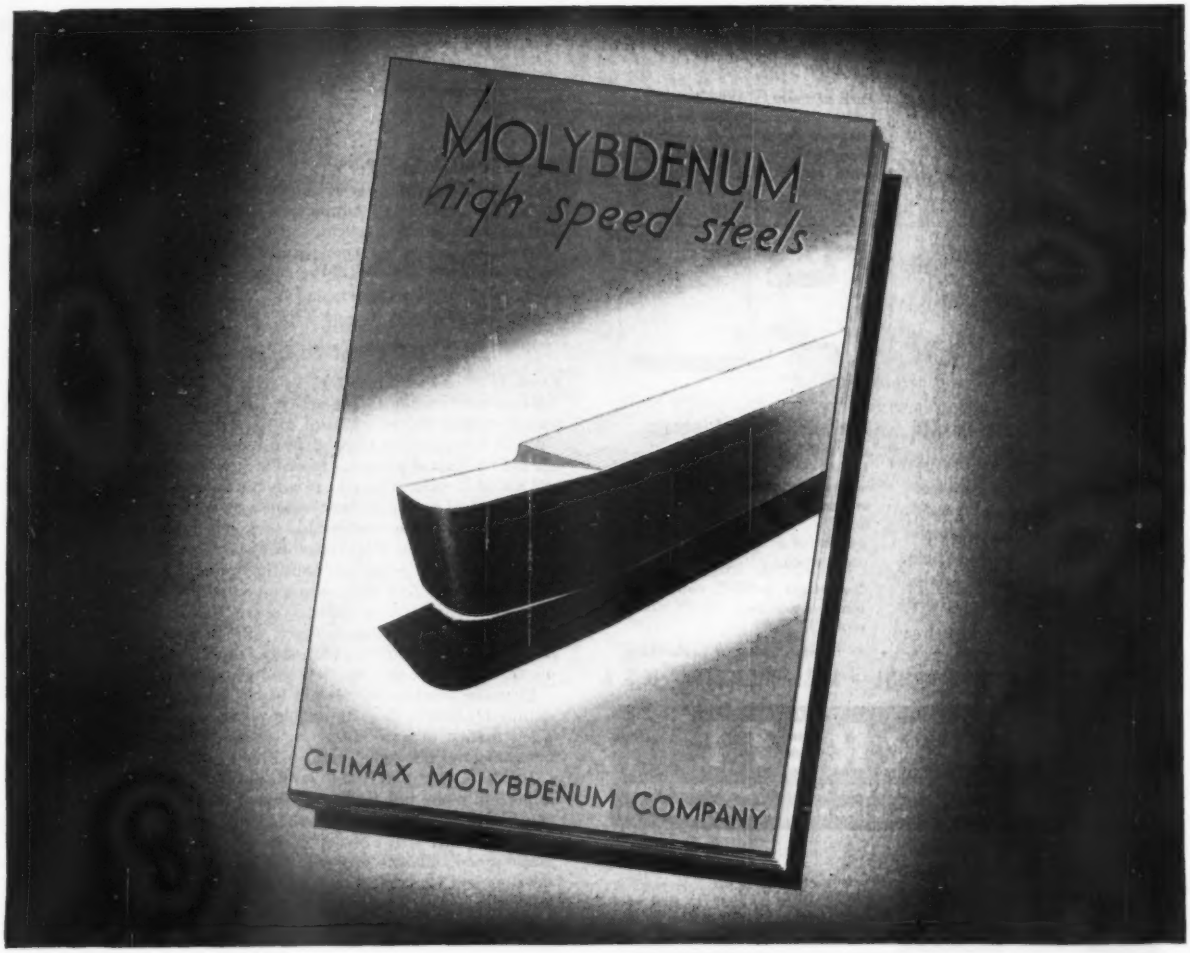
Glossology. — Judged by modern standards, grandfather lived a comparatively simple and leisurely life. He went his own way, blithely unconcerned about nucleonics, frequency modulation, vitamins, or jet-propelled airplanes. Yet these terms, which now have been injected into everyday language, bespeak the impact on our daily lives which science and engineering have brought about, particularly in the past half century. The ease and readiness with which new technical terms find their way into the general language, and the new concepts they bring along with them, are examined by PAUL COHEN, '35, (page 429). In addition to his vocation as mechanical engineer for the Sperry Gyroscope Company, Mr. Cohen wields an able pen, and rounds out a decade as one of The Review's editorial associates.

Revered. — In times such as the present, we need very much less of the common man and infinitely more of the uncommon man. Yet so much has been said and written in support of the former, that it is refreshing to come upon a spokesman who reveres and would give greater opportunity for the development of those of talent. Such a spokesman is H. B. PHILLIPS, Professor of Mathematics, Emeritus, whose article "What Is Democracy?" (page 433) emphasizes self-disciplined, individual liberty as the basis of a true democracy. After graduation from Erskine College in 1900, Professor Phillips received his degree of doctor of philosophy from Johns Hopkins in 1905. He was a member of the Department of Mathematics from 1907 until 1947, and its head for 12 years.

Accelerators. — Atoms have been chipped and even split, but the forces holding the nucleus together are still one of nature's best kept secrets. "Artificial Cosmic Radiation" by IVAN A. GETTING, '33, (page 435) tells what may be expected from recent research in atom smashing and gives a good account of the operation of cyclical accelerators for speeding up elementary particles. After his graduation from M.I.T. in 1933, Dr. Getting was Rhodes Scholar at Oxford University from which he received his doctorate of philosophy in 1935. He returned to M.I.T. in 1945 as associate professor of electrical engineering, after heading a division of the Radiation Laboratory and became a full professor in 1947.

Puzzle. — The Review runs a bit out of character this month to bring to its readers a novel crossword puzzle (page 444) designed by JOHN M. KECK, '23. Not only is this pastime devised by an alumnus of Technology, but the diagram itself contains many terms well known to M.I.T. students. Its design contains several significant symbols which all engineers will recognize.

Hobby. — Believing that all work (for which it is well known) and no play makes Jack a dull boy, the Institute inaugurated a student Hobby Shop in 1937. Now revitalized after World War II, the important part which this activity plays in student activities is recounted (page 441) by ISAAY STEMPNITZKY, 6-45, who is completing his studies for a doctorate in mathematics. Mr. Stempnitzky has been foreman of Hobby Shop.



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MAIL RETURNS

Approbation

FROM F. P. HANKERSON:

It was with great interest that we read the article "Roll out the Barrel" in the Trend of Affairs section of the April, 1948, issue of The Review. It was most excellent.

We would indeed like your permission to republish this, giving due credit to The Review and to the author.

Editor, The Wooden Barrel
St. Louis 2, Mo.

And Disapprobation

FROM THOMAS D. PERRY, '00:

Reference is made to the article "Roll out the Barrel" which appeared on page 310 of the April, 1948, Review.

While it is true that some of the present-day barrels are made by the age-old traditional process, especially the cheaper types for oils, paints, and all slack cooperage, that is only part of the story.

Plywood, or laminated beer barrels were developed some 10 years ago, in which I had some considerable part, and much better service can be obtained than in the older types. The staves are twice as wide, reducing leakage potentialities by one half; the frequent rupture of the wood on the bilge, where bent, has been eliminated entirely; and there is adequate in the strength of the bung stave. Oak is used for the inner and outer layers of the seven-ply stave, with cheaper woods for the central layers. This plywood construction has done much to conserve the supply of prime white oak, which is so much prized for barrel manufacture.

Plywood bourbon barrels are in the course of development under Arthur D. Smith, Jr., '23, and have passed excellent strength tests. Their ability to properly age spiritous liquors is under test, so far favorable, but not to be completed for a couple of years more.

It is to be regretted that the editorial staff of The Review missed this important phase in barrel development that has been presented before the American Society of Mechanical Engineers and published in many trade journals. It is not my desire to increase the thorniness of the editor's bed, but the cooperage industry deserves credit for its alert development along modern and efficient lines. You have inadvertently made this industry appear to be unaware of modern progress, which is quite undeserved.

Moorestown, N. J.

On Conservation

FROM MARSHALL N. WATERMAN, '24:

I think the articles on conservation by Dr. Ira N. Gabrielson which appeared in the January and February, 1948, issues of The Review were most worthwhile and interesting. The Review continues to be excellent.

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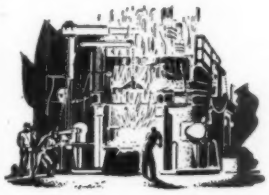

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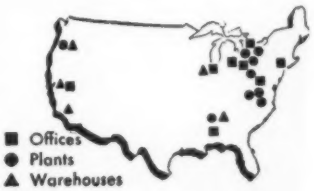

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VOL. 50 No. 8

Paul McC. Wiswell, '09

THE TECHNOLOGY REVIEW

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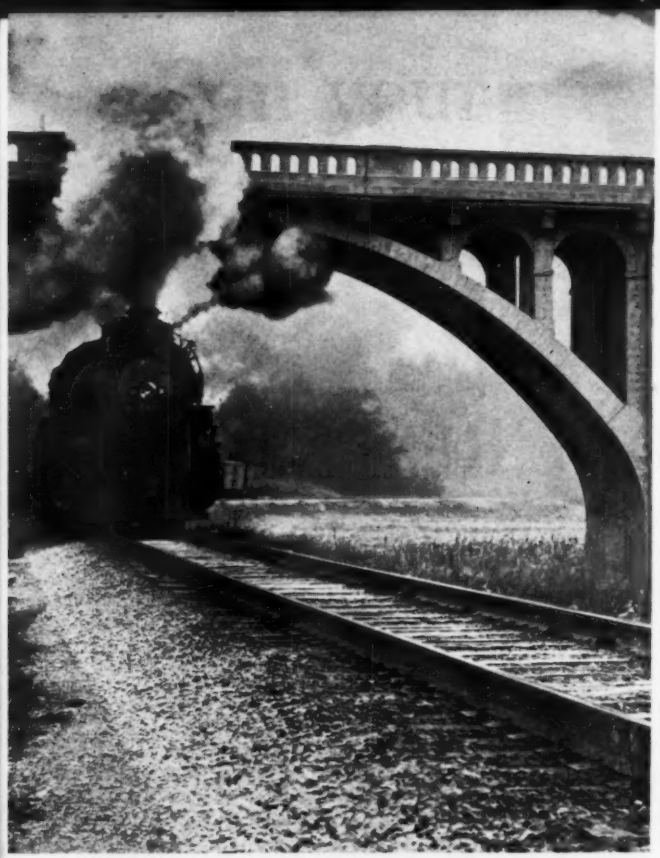

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Steel Rails across the Continent

Henry M. Mayer from Black Star

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THE
TECHNOLOGY
REVIEW

Vol. 50, No. 8 June, 1948

The Trend of Affairs

Butcher Viewpoint

THE common assumption that well-fed individuals are healthier does not hold true categorically when examined in the light of recent research. Undernutrition has, in fact, been found to increase resistance to infection of a certain type, although it does decrease resistance to other types of infection. Furthermore, restriction of food intake has been found to lengthen the life span. All of this research was done with small animals; the impossibility of exposing human beings to the experimental conditions required in such studies is obvious. Likewise, the extended normal life span of man makes difficult evaluation of influences affecting life span.

It is true that lowering the levels of certain vitamins below amounts considered to be optimal has been found to increase susceptibility to particular microbial diseases. For example, a shortage of the member of the vitamin B complex, known as biotin, increased susceptibility to paratyphoid infection, and also to malarial infection. Undernutrition likewise was shown to increase susceptibility to intestinal parasites, but in this study, lowered resistance was judged to be due to a general debilitation of the host, rather than to lack of specific dietary factors.

In complete contrast, however, deficiency of thiamine, vitamin B_1, was shown to increase resistance to a virus infection, poliomyelitis. Reduced intakes of minerals, considered to be dietary essentials, also improved resistance to a different virus. But these findings do not contradict the reverse observations with regard to the diseases mentioned in the previous paragraph, because of the differing nature of the respective etiological agents. The organisms causing paratyphoid infection are bacteria, microscopic plants; malarial parasites are microscopic animals; intestinal parasites are multicellular animals; viruses are submicroscopic entities not endowed with life in the sense we commonly recognize. The mechanisms of infection by, and resistance to, these different types of disease-producing agents may differ widely. Hence there is no reason to expect these mechanisms to respond similarly to undernutrition.

Nevertheless, the findings with regard to virus infections are striking in that they indicate undernourished organisms may have superior resistance to this important class of diseases. Explanations suggested for this relationship have been purely theoretical; a likely one postulates that parasitism of viruses upon the cells of the host may be so intimate that the virus is attracted only to well-nourished cells.

The diets used to study effect of undernutrition upon longevity were complete qualitatively in that they provided the "protective" factors, such as vitamins and minerals, in amounts known to be needed. But the diets were restricted quantitatively, by limiting total calories, or food-energy units. This limitation was accomplished in one of two ways: either by a continuous restriction of the amount of food supplied to the animals or else by alternating periods of free feeding with periods of total withholding of food. Continuous food restriction stunted growth of the animals; intermittent fasting did not.

Both types of food restriction produced significant lengthening of the life span, as compared with length of life of control animals that had been allowed to feed freely at all times. Therefore the available evidence on effect of feeding upon length of life is all in favor of restricted food intake, even when food limitation was carried to the extent of stunting growth.

At this point it must be stressed again that the observations summarized above were made on small animals. Therefore they are not necessarily directly transferable to human beings. Nevertheless, the findings indicate that undernutrition may have salutary effects, and in more than one direction. Hence the customary "butcher viewpoint" of aiming food habits toward abundance, with production of rapid growth and maximum body size, is not necessarily conducive to optimal well-being and a long life, and requires careful re-evaluation in the light of available and future research in this field.

Apothegms of Science

MUCH of the philosophy of science has been expressed epigrammatically by scientists with a literary bent, or by men of letters possessing a certain scientific insight. Thus a quotation from Thomas H. Huxley often seen in abridged form reads in full as follows: "Science is nothing but trained and organized common sense, differing from the latter only as a veteran may differ from a raw recruit: and its methods differ from those of common sense only as far as the guardsman's cut and thrust differ from the manner in which a savage wields his club." In the same vein George Santayana wrote: "Science is nothing but developed perception, interpreted intent, common sense rounded out and minutely articulated." "Science is a first rate piece of furniture for a man's upper chamber," said Oliver Wendell Holmes in characteristic phraseology, "if he has common sense on the ground floor." This cardinal faculty of scientists was characterized by Alexander Pope thus:

"Good sense, which only is the gift of Heaven,
And though no science, fairly worth the seven."

Pope, a prolific writer of philosophic verse, heralded the age of technical specialization in these lines:

"One science only will one genius fit;
So vast is art, so narrow human wit."

"Specialism, now a necessity," warned William Osler, "has fragmented the specialties themselves in a way that makes the outlook hazardous. The workers lose all sense of proportion in a maze of minutiae."

The advice of Edward Bulwer Lytton to those who seek to learn by reading was: "In science, read, by preference, the newest works; in literature, the oldest." "Books must follow sciences," runs the classic quotation from Francis Bacon, "and not sciences books." Pope, always quotable, rhymed in this fashion about rote learning in the sciences:

"How index-learning turns no student pale,
Yet holds the eel of science by the tail."

Another fundamental tenet of the scientific approach set down by Francis Bacon is: "Whatever the mind seizes upon with peculiar satisfaction is to be held in suspicion." A primary aim of research was articulated by W. S. Jevons thus: "Science arises from the discovery of identity amidst diversity." "Man cannot make principles;" said Thomas Paine, "he can only discover them." Walter B. Cannon pointed up the influence of words on thought, and at the same time epitomized the present limitations of the biological sciences, when he wrote: "In a biological system all the elements of which cannot be known, the words 'must,' 'absolutely,' 'doubtless,' and 'invariably' should be used not at all or with extreme caution."

William Temple indicated a prime basis of scientific motivation by stating: "Science has its being in a perpetual mental restlessness." "It is not the *possession* of knowledge, of irrefutable truths, that constitutes the man of science," Karl Popper wrote, "but the disinterested, insistent *search* for truth."

An adage with technical import, so timeworn that the identity of its author has been buried in the mists of antiquity, is: "The exception proves the rule." Although this aphorism is widely quoted today, it is usually misinterpreted; for it is a direct translation of the Latin *exceptio probat regulam*, so that "proves" here means "tests." The same meaning of prove is to be found in a quotation from Paul, the Apostle, that incidentally is a good maxim of the scientific point of view: "Prove all things; hold fast that which is good."

Selection for Resistance

THE struggle for existence," said Spencer, "leads to the survival of the fittest." Among the odder consequences of that principle have been a series of hidden and almost unknown defeats in our battle against our insect and bacterial enemies. An illustration is the increasing number of reports that many strains of microorganisms are developing resistance to penicillin and streptomycin, just as others did a few years ago to the sulfa drugs. In fact, starting with cultures of meningococcus which succumbed readily to streptomycin, scientists have been able to isolate strains which "actually required streptomycin for growth and multiplied best in high concentrations of the drug." Like the man who "recovered of the bite — the dog it was that died," when mice were infected with this particular variety of microorganism, the untreated mice managed fairly well; the ones treated with the antibiotic succumbed. The ability to become tolerant of antibiotics has, unfortunately, been noticed with a wide range of microbe species and genera.

All this is no disparagement of chemotherapy and of the many antibiotics which have been investigated during the past decade. But it does mean that there is danger in using these powerful new drugs on trivial illnesses or in concentrations insufficient to deliver a knockout blow to the invading organisms. It implies also that highly resistant strains of important diseases may become prevalent enough to reduce the value of present antibiotics to the physician. On the other hand, chemists have been busy uncovering many new varieties of penicillin and streptomycin, and will very likely find ways of altering the structure of naturally produced types in a manner that will evade the defenses being created by the disease germs. But as long as living tissue retains its capacity to adapt itself to hostile environments, the unveiling of a new and powerful drug will be no guarantee that a specific disease has been permanently conquered.

Doubts are even beginning to arise about DDT. The discovery of powerful new insecticides, particularly DDT, has raised the hope that large-scale control of some of our more serious insect pests will now be feasible. It has been suggested, for example, that huge tropical areas, previously graveyards because of insect-borne diseases, may be opened to successful colonization by the use of these chemicals. Although the dream may in time prove true, the insects are not co-operating. Unless dosage of an insecticide is extremely heavy and thorough, there are generally a few survivors in a treated area. It has been demonstrated that these survivors can become the ancestors of lines a great deal more resistant than was the original population. Worse still, for man's point of view, those who withstand one poison show a tendency to increase the extent of their immunity to many others.

The Bureau of Entomology and Plant Quarantine, working with funds supplied by the Office of the Surgeon General, United States Army, took the 10 per cent of house flies that had survived a measured application of DDT and bred from them a special colony. Each generation in turn was similarly (*Concluded on page 450*)

A. Devaney, Inc.

"Men ever had, and ever will have, leave to coin new words well suited to the age."

Translation of Horace's *Ars Poetica* by Wentworth Dillon, Earl of Roscommon

The Shadows of Science

By Paul Cohen

THE impact of science on civilization, its huge and growing presence in our everyday lives, is a theme which, by its sheer immensity and complication, has smothered most of the authors who have attempted to deal with the subject. In turn, it has been beaten to death by repetition. But if the substance cannot readily be pictured, the shadow may perhaps suggest the image.

Accompanying every event or thing that intrudes upon our consciousness is a word; for words are the symbols with which our minds are related to the external world. It is a measure of the growth of science, therefore, that words of technical and scientific origin, which once entered the common tongue one by one and at irregular intervals, are now marching into the layman's language by squads. New arts, new mechanisms, new concepts too important (and too disturbing) to be ignored by any but the most obtuse, are forcing their way into our lives; their shadows appear on the tongue and in the literature of the common man.

The problem is universal. For example, in translating the charter of the United Nations into Chinese, it was necessary to devise almost 2,000 new combinations of ideographs. The standard Chinese dictionary, compiled under imperial supervision during the Eighteenth Century, appears to have overlooked some of the semantic problems of the atomic age. Scientific terms are among the biggest stumbling blocks in languages other than Chinese, and an atomic energy glossary has been prepared in the five official languages of the United Nations.

Considering only publications of general circulation, we find in them today scores of words which, although widely understood and used without explanation or apology, are of the most recondite origin. Women's journals discuss antibiotics, such as penicillin and streptomycin, with the other side of the page, as likely as not, devoted to the virtues of detergents in washing machines. Records are broken as jet- and rocket-propelled airplanes travel at supersonic speed, sometimes through the stratosphere. Geneticists report new and startling mutations produced by x-rays, neutron beams, and other man-made radiations. Television programs travel between stations along coaxial lines and are received in the home by sets that receive amplitude- or frequency-modulated radio waves with equal ease. Oddest of all is that millions of laymen can plow through such text without reaching for a dictionary. It's just as well, too, for the dictionaries would frequently fail them.

Radar now appears in the news in connection with the towing of barges across New York harbor in foggy weather, guiding commercial planes on which we have been (or might be) passengers, or signaling to such a piece of public property as the moon. But the term, which was coined by the United States Navy as an abbreviation for the phrase "radio detection and ranging," was presumably completely unknown even to the technical world (aside from those directly concerned with it) until April 25, 1943, when the first Army-Navy press release on that subject was issued.*[1] Two lesser known cousins of radar that seem due to remain in civilian life are loran and sonar. The former is an abbreviation of the phrase "long range aid to navigation," and the latter term, coined at Harvard University to describe a "sound navigation and ranging" device it had developed, was promptly applied by the Navy to all underwater sound gear.

World War II left another significant phrase with us — guided missile. Actually it is the name and not the device which is new. Weapons whose paths are automatically controlled after launching are at least as old as the Whitehead torpedo.† Radio controlled or "drone" planes

* See bibliography at end of article for numbered references.

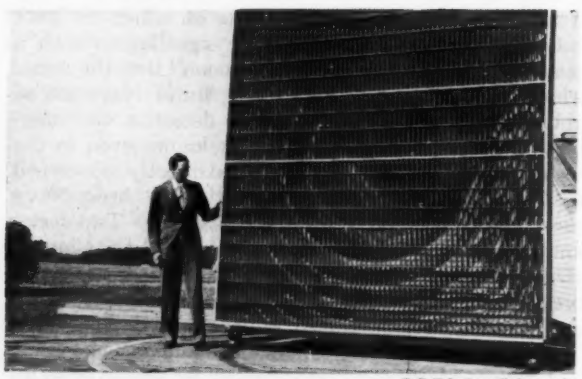
† Torpedo, meaning the electric eel or ray, and derived from the Latin *torpere*, stiff or numb, entered our language about 1520. As a noun, meaning a submarine missile or mine, it has been in use since our Revolutionary War. With the invention of the Whitehead torpedo, which made it an automatically steered, self-propelled device, it became a far more significant weapon, and by 1879 we had the verb "to torpedo," meaning to destroy or damage with such a missile. But the word has continued to progress. Witness such usage[2] as the New York *Times* headline "Moscow Says U. S. Torpedoes Parley." In a way, the torpedo has been the foster mother of the word servomotor, for one of the first servo or "slave" mechanisms to be used was the little pneumatic engine that amplified the signals from the torpedo's controls into a force that could move the rudders.

were experimented with during World War I. But the first use of a radio-controlled missile in combat (by the Germans) is said to have occurred during 1943, and only with the steady pounding of London, and later Antwerp, by the V-1's and V-2's did the public realize the nature of this new threat to life and property. The guided missile will very likely also cause important tactical changes on the battlefield, but it is the long-range missile aimed at a metropolitan area that grips the general imagination.

King of the guided missiles, as of the moment, is the V-2; and stark as is this designation, it calls up a sharp, detailed picture in the mind of almost every person who sees a movie or reads a newspaper regularly.‡ Mainly because the V-2 has been making well-publicized trips

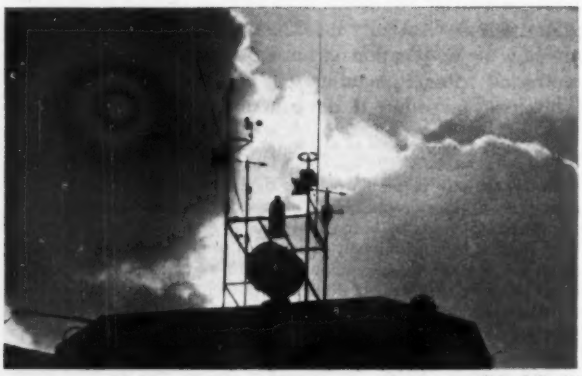
Boeing Aircraft Company

▲ *Jet Propulsion*



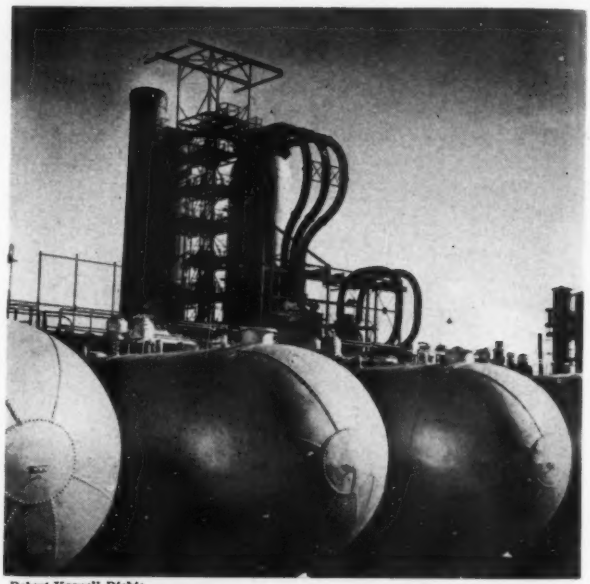
Bell Telephone Laboratories

▲ *Microwaves*



Samuel Kravitt

▲ *Meteorology*



Robert Yarnell Richie

Petroleum ▲

deep into the ionosphere, the outermost shell of our atmosphere, the Sunday supplements have broken out with a rash of terms that were once the sole concern of meteorologists and physicists. The ionosphere is so called because it contains many layers heavily charged with ionized particles which, fortunately, are excellent reflectors of radio waves and make long-range, short-wave radio communication possible. Far below is the troposphere, the shell of air immediately in contact with the earth and extending to a height of approximately five to 10 miles. *Tropo* means turn or change, and the region of the troposphere is indeed one of varying temperatures and wind velocities, of storms, calms, and clouds. Above the troposphere lies the stratosphere, entered occasionally by the higher flying of our planes and extending to about 50 miles above sea level. The stratosphere was so named about 40 years ago because (and this is the definition still current in our dictionaries) it was thought to be of nearly constant temperature throughout its thickness. Recent investigations, and particularly the V-2 flights, have dispelled that illusion, and we have one more scientific term with a derivation no longer with its original meaning.[3]

Vitamine, now spelled vitamin, is another example. It was coined by Casimir Funk in 1912 from the Latin *vita*, meaning life, and the chemical term *amine*, which is an organic derivative of ammonia, since he thought that the vitamins were all amines. They are, of course, of a far more varied structure. There is also the dinosaur, which Sir Richard Owen thought was a single species (happily extinct) of large and savage lizards. He therefore combined the Greek words *deinos* or terrible, and *sauros* or lizard.[4] That was in 1841 and 17 years before Darwin published *The Origin of Species*. In the intervening century, however, the paleontologists have been busily disinterring dinosaurs by the hundreds, and it is now apparent that many of them were small; some were very likely timid in disposition, and none of them was truly a

‡ Undoubtedly the term is not for the dictionaries. How can a properly reared lexicographer have dealings with a word that is a cross between a capital letter and an arabic numeral?

Edgerton, Germeshausen, and Grier

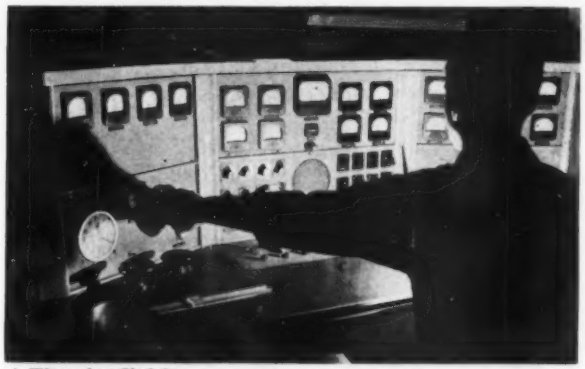
▲ *High-Speed Photography*

lizard. Today the word dinosaur is no more specific than the phrase "hoofed animals." It is simply a way of referring to several related orders of extinct reptiles.

From time to time the scientists have succeeded in creating phrases as impregnated with drama, mystery, and adventure as any in the language, and the sonic barrier, the wall of sound, must fall into this category. The speed of sound was interesting scientists in Newton's time, for Sir Isaac [5] derived an equation (incorrect) for determining it. But it became a subject for newspaper discussion just before the outbreak of World War II, as an item in the debate on whether it would ever be possible for a plane to push through the air at velocities greater than that at which sound is propagated. Then, as propeller-driven fighter planes increased in speed, they began to get into trouble, sometimes with fatal consequences, as they approached the speed of sound in power dives. With the revitalization of rocket and jet propulsion, assaults on the sonic barrier in man-carrying planes have increased in frequency and interest.

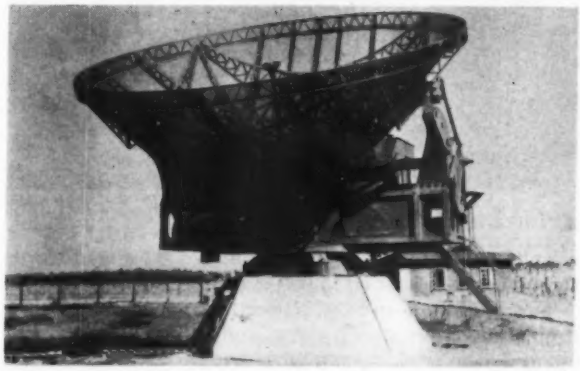
It is fairly well known, of course, that the word rocket is of considerable antiquity. It entered the language about 1611, and is derived from still older French and Italian terms. The French *roquette* (a colewort) and the Italian *rocchetta* (bobbin or spool) which, in turn, is a diminutive of the Italian *rocca* (distaff) all have reference to the shape of early fireworks rockets. Jet propulsion[6] is a little more up to date. Not until 1866 did the British Admiralty build a ship of 1160 tons, propelled by a water jet (based on a patent 17 years older), to see if it was any more efficient a method than propellers. (It wasn't.) The word "jet," meaning to spout or spurt forth, dates from 1692, and as applied to an emission of fluid from an orifice, has been in use since 1696.

Careful distinction is now made between subsonic, transonic, and supersonic flight, for the manner in which the air flows around a body in each of these zones is radically different, and the point at which the flow changes depends not so much on the speed in miles per hour as on its relationship to the speed of sound in the immediate vicinity. While there are no sharp, clean-cut physical changes to mark the transitions, the subsonic range is generally considered to include speeds up to about 0.8 the speed of sound. The transonic region extends from 0.8 to about 1.2 times the speed of sound, and thereafter is the realm of the supersonic. Transonic seems to be a fairly new term, for only with the airplane is the sonic barrier approached and penetrated rather slowly. With shells and rockets, which achieved supersonic speed (that greater than the speed of propagation of sound) very quickly, there was little occasion to study the unsteady and somewhat inexplicable flow phenomena of the transonic region. The word supersonic, on the other hand, is close to 30 years old, and appears to have been appropriated, with new meaning, by the airmen from the physicists, for supersonic and ultrasonic both



A. Wittman from Black Star

Nuclear Physics ▲



■ *Radar* ▲

Westinghouse

High-Speed Radiography ▲

▼ *Crystallography*

F. S. Lincoln, '22

George H. Davis Studio

▲ *Electron Microscopy*

refer to sounds with frequencies above those audible to the human ear, that is, 15,000 cycles per second or more.

The matter of suffixes is worth a little attention in itself. *Sub*, *super*, *trans*, *infra*, and *ultra* are, of course, all of Latin origin. As used currently in English, *sub* means under, below, at the bottom of. So, essentially, does *infra*. *Super* means higher in some rank or quality. *Trans* means across or through, and *ultra*, bearing some of the connotations of *super*, means extreme, exceeding the limits of its class. Used as a word, it once meant any sort of an extremist, as in the French term *ultraroyaliste* or *ultrarévolutionnaire*.

It is not to be expected that science would be immune to the "characteristic American habit of reducing complex concepts to the starkest abbreviations," a habit which Mencken points out [7] "was already noticeable in Colonial times . . ." Fortunately, the public did not have to put up with trinitrotoluene (TNT), dichlorodiphenyltrichloroethane (DDT), or the weed killer and suburbanite's friend, 2–4–dichlorophenoxyaceticacid (2,4,D). The technicians who had to deal with these elephantine expressions daily soon resorted to terser symbols. They are showing no disposition to dally with amplitude and frequency modulation, either. Instead, the public buys AM-FM sets. Since several types of pulse modulated communication systems are already under development, we may have to face the prospect of buying AM-FM-PM sets.

The first year in which the letters FM appear in the *Industrial Arts Index* is 1940, although the paper by E. H. Armstrong that started FM's important practical applications, "A Method of Reducing Disturbances in Radio Signalling by a System of Frequency Modulation," was published in May, 1936. Armstrong, however, did not coin the abbreviated term. In a paper published in 1930 Balth van der Pol [8] of Eindhoven, Holland, was able to say that "A certain amount of discussion has taken place during the last years . . . [about] frequency modulation."

As for the greatest science story of our time — the story that starts with the discovery of the electron and ends its first chapter with the atomic bomb — it has had, as scientific developments go, an almost unique effect on the public's vocabulary. Darwin's theories and the announcements of Copernicus might have stirred men more deeply than the demonstration of nuclear fission, but those concepts could still be tied, here and there, to everyday experience and described in everyday words. Nuclear physics, however, is the most esoteric of sciences, made up of things that are neither matter nor energy, behaving in a manner that sometimes appears to be not merely mad but also impossible. Except for a few determined intellectuals, the public did not follow the discoveries in this field too closely, or take them very seriously. There were exceptions, of course. Those who took high school or college science courses had to learn at least something of atoms and electrons but such elementary introductions were far removed from the earth-shaking prophecies of relativity and quantum mechanics. Radium and radioactivity, primarily because of their association with cancer (rather than their implications regarding the structure of matter) gained some public interest. Even a popularizer like Wells could not make people take the same intense interest in Rutherford's theories that it did in Freud's. In *The World Set Free*,[9] published in 1914, Wells set up an extraordinarily acute picture of atomic war (one that may become more accurate as time goes on) and saw it greeted with apathy.

Generally, as new "particles" were discovered, as new theories evolved, and as new words were coined to describe both particles and theories, the public did not absorb the new vocabulary directly from those whose minds had made the original conception. Instead, they tried to swallow it all in one gulp from the Smyth report.[10] Now that the flood gates are opened, the newspapers speak, without blinking, of cyclotrons, atomic piles, isotopes of both stable and unstable variety, several brands of uranium, a whole string of elements once listed only in the periodic table (and a few not even there).

A case in point occurred during the assembly of a new synchro-cyclotron for Columbia University in December, 1947. This event was treated by the newspapers with all the fanfare of a battleship launching. The New York *Daily Mirror* carried the story under a two-column head on page 36 using a minimum of technical terms. The New York *Times*, naturally, started the story on the front page and spared the reader nothing. One paragraph read: "The protons accelerated in the (*Continued on page 462*)

What Is Democracy?

Individual Freedom to Improve Human Welfare, Based on the Diversity of Chance, Is the Essence of Democracy

By H. B. Phillips

AMONG the leading nations of the world, during the last half century, those with democratic form of government have had comparable populations and vastly greater resources than those with autocratic form. Yet at no time during that period has democracy seemed less safe than now. This strongly suggests that in recent times the democracies have not made effective use of their resources in promoting their own interests. If, in the future, these resources are to be more effectively used, we must know what democracy is, and, in particular, what makes a democracy strong.

Democracy is usually defined as government by the people; government in which supreme power is retained by the people, and exercised either directly or through representatives. Examples show that governments which qualify as democracies under this definition differ widely in their success in promoting the welfare of the people. Some are highly successful, some very unsuccessful. If, then, democracy is to be a necessarily desirable form of government, the definition must be further restricted. With this in mind, many writers select particular features, which are often found in democracies, and use these as the essential characteristics. Among such features are three emphasized by Aristotle and included in practically all treatments of democracy since his time. These are: majority rule, equality, and liberty. As a basis for discussion we might then define democracy as government which includes these features.

Unfortunately, however, these features cannot coexist, each in its entirety. If there is majority rule in everything, there is no liberty. If I am forced to act contrary to my wishes, it makes no difference to me whether this force is exerted by my neighbors or by a dictator. Liberty consists in the things left to individual rule. Thus, majority rule and liberty are not compatible. Similarly, equality and liberty are not compatible; for forced equality is just as great a restraint as forced inequality. And even majority rule and equality are not necessarily compatible; for the majority, as has often happened, may find it undesirable to have equality. Thus majority rule, equality, and liberty are mutually incompatible. Yet throughout history these have been the principal characteristics of democracy. Their incompatibility is a prominent cause of confusion and often of weakness in democracies, for the proponents of particular schemes select the characteristic which best favors their views and get the support of well-meaning people on the ground that any other action is undemocratic. If a democracy is to be successful, it must therefore choose which of these characteristics is to be fundamental.

If forced to choose, probably most people would take majority rule as the central feature of democracy. An objection to this, pointed out by Aristotle *[1] is that practically all governments have majority support. If, for example, absolutely honest elections had been held in Germany, Japan, and the United States just before World War II, there is little doubt that Hitler and the Japanese emperor would have won by greater majorities in their countries than Roosevelt in the United States. Yet no one would claim that Germany and Japan were better examples of democracy than the United States. To this, some reply that the remedy is education — that the people in Germany and Japan should have had better instruction. This is a curious suggestion by those who define democracy as majority rule since it would let a small group of teachers determine what the majority shall think. That is precisely the system of propaganda which worked so perfectly in Germany and in Japan.

The logical basis for majority rule is the notion that the larger the number of people who have a given belief, the greater is the probability for that belief to be correct. This is the argument of James Bryce [2] and, in a guarded way, of Herbert Spencer.[3] Applied to matters of a political nature, this argument has serious defects.

It assumes, first of all, that people form their own opinions, whereas we know political opinions are mostly acquired. The average opinion is thus merely the weighted mean of the ideas expounded by sources from which opinions emanate, and the influence of those sources is determined by features unrelated to the particular issue. That the spread of an opinion is not dependent on its truth or falsity is illustrated by the singing commercials on radio programs. Large sums are spent on those commercials because they are found to be effective in forming public opinion.

This state of affairs is not much improved by education; for, as James Bryce says: "Attainments in learning and science do little to make men wise in politics. Some eminent scientific men have been in this respect no wiser than their undergraduate pupils." [4] This failure of education comes about, I think, because the principal effects of education are to increase knowledge of the past and to improve ability to reason, whereas each political problem has so many new features that past experience is of little value and has so many unknowns that the validity of a political conclusion is rarely determinable by reason.

Thus, whether the voters are educated or not, we have little reason to expect that majority rule will be better than average rule, and average results — which we may truly construe as mediocre — are not good enough for a strong democracy. Still, many people choose majority rule because they consider minority rule the only alternative. In this, however, they overlook the third possibility,

* See references at end of article.

namely, individual rule, under which there is no single action, but each person is permitted to utilize his abilities for general progress as he sees best.

Others choose equality as the essential feature of democracy. Thus, in a statement advocating Universal Military Training, General Eisenhower said: "The fundamental principle of democracy is equality — equality of burden as well as equality of opportunity." [5]

An objection to equality as a fundamental principle is that equality is not an absolute characteristic. What is important to me is not whether I am equal to another — for no two persons are ever entirely "equal" — but to how much I am equal. Perfect equality can be provided by prohibiting the labor-saving machinery, to which workmen frequently object, and letting the men work longer hours, but this does not result in a high standard of living. In many communities there is agitation to reduce the amount of time given to difficult subjects, such as mathematics and physics, in the public schools and to concentrate more on the "cultural" subjects which can be assimilated with less effort. Such a program provides greater equality in education because larger numbers are exposed to certain minimum standards, but may result in a nation which is easier to conquer in case of war.

These are instances of equality before the law and we are told that equality in a democracy always means equality before the law. But, in practice, this legal restriction is often forgotten. For instance, T. V. Smith says: "equality must mean a more equal sharing in income, if not in wealth, than is now possible"; [6] Carl L. Becker speaks of "that equality of opportunity and of possessions without which democracy is an empty form"; [7] and James Bryce says: "Even if the law does not — perhaps it cannot — prevent the accumulation of fortunes, these will be few and not inordinate." [8] Thus most writers who discuss equality have in mind some form of economic equality, and the income tax statutes are deliberately made discriminatory in an effort to produce this type of equality.

Against economic equality there is a fundamental objection. While progress continues, wealth and income will be subject to chance, and in a field subject to chance, values are distributed according to some form of statistical law. Thus under widely varying conditions incomes are distributed at least approximately according to Pareto's law. [9] The precise form of these laws depends on the things distributed, but they all agree in the fact that equality is obtained only when the values are all zero. We may, therefore, expect equality of income only in a community where incomes are all substantially zero.

An interesting illustration of the mode of life which may be anticipated under conditions of complete equality of possessions was given by Charles Darwin. Before he became famous, Darwin spent some years on the English ship *Beagle* making observations of life in various parts of the world. In Tierra del Fuego he observed savages in a lower state of improvement than he thought existed in any other part of the world. Members of these tribes did not impress him as of the lowest mental capacity, yet they had no leaders and no form of government. In a country where there was frequent ice and snow these savages had only decorative scraps of clothing and almost no shelter. Being curious as to why their condition should be so poor, Darwin observed them closely. He noted that they practiced an extreme form of communism, that if one family had food it was shared equally with the others, that if a piece of cloth was thrown to them it was torn into bits and distributed. Darwin reasoned that before the condition of these savages could be much improved, leaders would have to receive preferred treatment, that in the absence of such preference "The perfect equality among individuals comprising the Fuegian tribes must for a long time retard their civilization." [10] In these tribes Darwin was observing an instance of economic equality, a condition which can obtain only at zero.

It does not seem, therefore, that a democracy based either on majority rule, or on equality, has much chance of success. Whether government based on individual liberty has a better chance depends on whether, in political affairs, it is possible to make definite plans which have a high probability of success. If it is possible, it would appear that we should find the ablest planners and give them supreme authority. There will then be no need for majority rule and the plans should provide the amount of equality and liberty that is best. Objection might be made that under this arrangement people would not be happy, and consequently some less perfect system must be adopted under which people will be more content. The answer is that if definite planning can produce the greatest success, some totalitarian nation will succeed so well that the democracies will have to adopt the same methods or become unimportant.

Some of the greatest men have evidently thought the planned state could succeed. This is illustrated by Plato's *Republic* and the various ideal states created by social dreamers since his time. A very brief study will indicate, I think, why the authors of these schemes had so much confidence in planning. These authors thought the future world would differ very little from that in which they lived. Consider, for example, More's *Utopia* which has contributed our modern name for such dream states. Sir Thomas More was one of the ablest men of his time, and of such high character that he submitted to beheading rather than to compromise on a matter of moral principle. Yet in his *Utopia* "The husbandes chastice theire wyfes." [11] Apparently chastising wives was so common that it did not occur to More that men would ever give up this domestic pastime.

In a world so completely fixed, planning is certainly possible. But the actual world is perpetually changing in directions which are entirely unknown in advance. In such a world there is no rational basis for planning. This is because all plans are concerned with the future. Whether a particular measure is good or bad is determined by its influence on future welfare. That future will, however, be profoundly influenced by the existence of single individuals, single discoveries, or even single ideas, all of which are not only unpredictable but not even logically determined in advance. The role of the political forecaster is like that of the astronomer trying to determine the orbit of a planet the motion of which could be materially influenced by the behavior of a single one of its atoms. In Calvin Coolidge's administration who could have predicted that within 10 years the United States Government would be paying men not to work? During the Roosevelt administration who would have limited production if he had thought that within a few years lives would be needlessly sacrificed through lack of those very supplies for which people were being paid not to produce? (*Continued on page 456*)

Artificial Cosmic Radiation

What Keeps Atomic Nuclei from Exploding? Postwar "Atom Smashers" Now Going into Operation Have Sufficient Energy to Find the Answer to This Query

By Ivan A. Getting

THERE are two main aspects to the investigation of cosmic radiation. The first is the study of the cosmos through the observation of the radiation. The second is the use of the radiation in the investigation of the structure of matter itself. Of course, both of these aspects are of primary concern to scientists in extending the forefront of man's knowledge. Strangely enough, in regard to size, these two fields of research are at the extremes of man's experience.

Cosmic radiation originates somewhere outside of our own Galaxy, the Milky Way. Cosmic radiation and light from extragalactic nebulae are the only ways we have for reaching beyond the Milky Way. The nearest edge of our Galaxy is some 25,000 light-years away. Since a light-year is about six million million miles, the distances are indeed large and the name, cosmic radiation, appropriate.

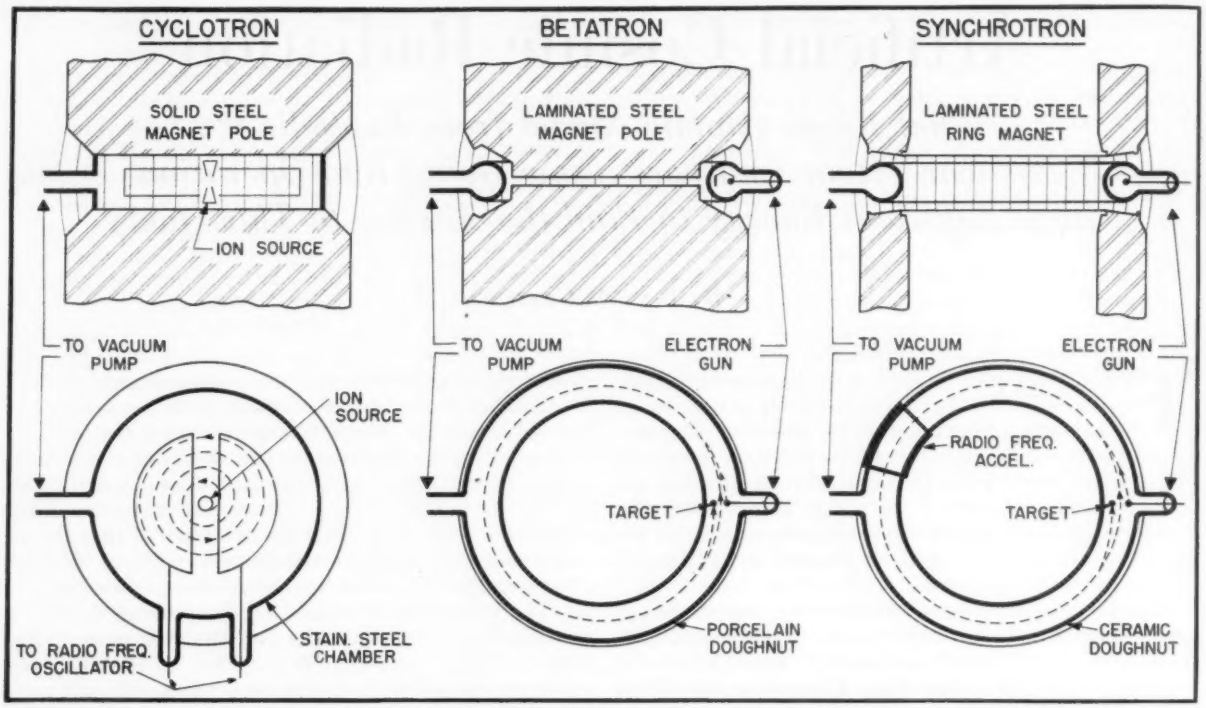
Turning now to the use of cosmic radiation as a tool for investigating the atomic nucleus, we reach the other extreme of man's experience. The radius of the average atomic nucleus is a millionth part of an angstrom unit, which, in turn, is roughly one-sixteen million millionth part of a mile. It is interesting to observe that the dimensions with which we usually deal are about the mean between the two extremes of man's comprehension.

The connection between the two fields of cosmic investigation comes from the fact that the primary cosmic radiation consists of particles, presumably protons or ionized hydrogen atoms, which, through some method as yet unknown, attain energies of from a few billion electron volts to even a billion billion electron

The Physicists' "Elementary Particles"

Particle	*Mass*	*Electric Charge*	*When Created or Lost*	*Uses*
Photon	None	None	Created when an electric charge radiates energy; lost when its energy is absorbed by a charge	Makes up light and other electromagnetic radiation. The carrier of electrical energy
Electron	0.9017×10^{-27}g. About an octillionth of a gram	-1.602×10^{-19} coulomb. About two tenquintillionths of a coulomb, negative sign	Sometimes created in, and ejected from, a nucleus. Can be created, along with positron, near a nucleus. Emitted by hot metals. A constituent of cosmic radiation	Makes up outer structure of all atoms. Responsible for their chemical behavior. Responsible for electrical conduction in metals and electron tubes
Positron	0.9017×10^{-27}g. Same as electron	$+1.602 \times 10^{-19}$ coulomb. Same magnitude as electron, positive sign	Sometimes created in nucleus. Can disappear by combining with electron, leaving two photons	A secondary constituent of cosmic rays. Too transitory to be of much other use
Proton	1.6734×10^{-24}g. About 1850 times the electron mass	$+1.602 \times 10^{-19}$ coulomb. Same as positron	Can be changed into a neutron inside a nucleus, producing a positron or destroying an electron in the process	The nucleus of an ordinary hydrogen atom. A constituent of all nuclei. Responsible for the nuclear charge and part of the mass. Also present in cosmic rays
Neutron	1.6747×10^{-24}g. Slightly heavier than proton	None	Can be changed into a proton inside a nucleus, producing an electron or destroying a positron in the process	A constituent of all nuclei. Responsible, together with the proton, for the nuclear mass. Most nuclei contain nearly equal numbers of neutrons and protons
Neutrino (existence possible)	Much less than electronic mass, possibly zero	None	Perhaps created along with electron or positron when proton changes to neutron or vice versa	Introduced to explain the energy balance when electrons or positrons are emitted from radioactive elements
Meson	0.2×10^{-24}g. About 200 times the mass of the electron	$\pm 1.602 \times 10^{-19}$ coulomb. Two particles with opposite charge, similar to electron-positron pair. Perhaps also a neutral particle	Possibly created during nuclear radiation of energy. Probably produced *via* a heavier meson called the π meson which is 1.8 times as heavy.	Possibly an analogue of the photon, carrying the energy of nuclear forces. Present in cosmic rays

Note: The disappearance of mass requires the production of about a half a million electron volts of energy for each electron-mass unit which disappears. An equal amount of energy must disappear when an equal mass is created. Electric charge can be transferred from particle to particle during a change, equal amounts of positive and negative charge can be created simultaneously, but total *net* charge cannot be altered.



Schematic diagrams of the three principal types of cyclic accelerators for elementary particles. In these machines the particles to be accelerated are made to travel in orbits during each of which energy is imparted to them.

volts.* The concentration of energy in some individual protons is far greater than can be attributed to the total disintegration of even the heaviest atom — uranium. Therefore, it is commonly held that some sort of cyclic acceleration by electric fields (or perhaps an induction field arising from a time-varying magnetic field) over tremendous intergalactic spaces may explain the tremendous energy which is observed in cosmic rays. It is only through the use of cosmic rays, or recently developed particle accelerators, that we are able to have at our command sufficient energy concentrated in a single particle to make a successful attack on the atom, and to learn the structure of its nucleus.

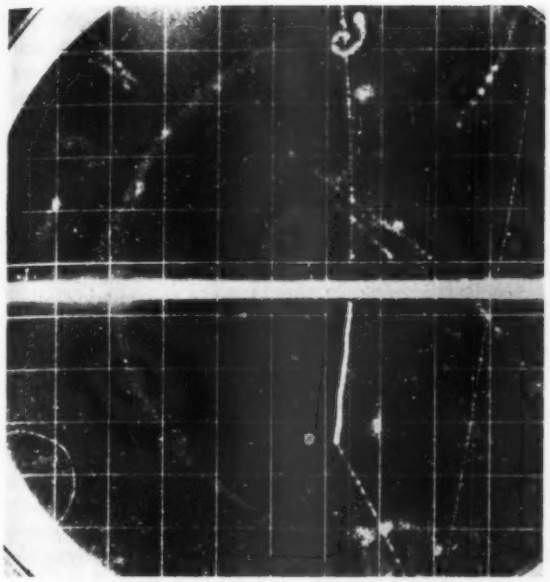
The atomic nucleus is a veritable fort. It is surrounded by its cloud of electrons which protect the nucleus against all small-scale assaults. These electrons are normally responsible for the emission of light and x-rays by atoms. Not until an external particle has energy of the order of a few hundred thousand electron volts is it capable of making the slightest impression on the make-up of even the frailest of nuclei. All nuclei are susceptible to modification, however, when the bombarding particle has energy of from a few hundred thousand to approximately 20 million electron volts. In general, the process of nuclear disintegration can be visualized as taking place in two steps. When the nucleus is bombarded by an external particle of sufficient energy to penetrate the electron cloud barrier, a compound nucleus is formed. Such a compound nucleus may be inherently unstable, or it may be normally stable except for the large amount of kinetic energy brought in by the impinging particle. In either case, it breaks up, usually, but not necessarily, with the emission of a single particle. The remaining nucleus may or may not be stable. If it is not stable, it will achieve stability by emitting a positron or electron at some later time. Such a nucleus is called artificially radioactive.

But it is at much higher energies — until recently found only in cosmic radiation — that the experimenter has found greatest possibilities. With exceedingly high energies, he can begin to work with particles never previously observed, can witness the creation of matter or can produce explosions of atomic nuclei. In this realm of physics, better than anywhere else, the theoretical physicist can test the validity of extrapolating macroscopic concepts to physical dimensions and time intervals where no real, logical argument for such extensions can be applied; only experimental results can lead the way. The more energetic the particles, the closer they can come to the constituent elements of the nucleus. As the distances diminish, the greater becomes the expected departure from electromagnetic laws derived from macroscopic experiments. In fact, new forces must be found to explain the stability of nuclei themselves; and strange indeed are the interpretations which result.

Perhaps the greatest single discovery in cosmic-ray investigations was the independent discovery of the meson by J. C. Street and E. C. Stevenson at Harvard University, and by Carl D. Anderson and Seth H. Neddermeyer at the California Institute of Technology. Intermediate in mass between the smallest of all known particles (the electron), and the lightest of the atomic nuclei (the proton), the meson does not exist in a free state at rest. It is created as a by-product of collisions by the cosmic radiation in the earth's upper atmosphere. On the average, the meson lives but a few microseconds and then breaks up.

The meson was very anomalous at first, until evidence connected it with a particle proposed by a Japanese

* An electron volt is the amount of energy change experienced by an electron as it passes through an electric field of one volt. (1 electron volt = $1.6 \times 10 = {}^{-12}$ erg.)



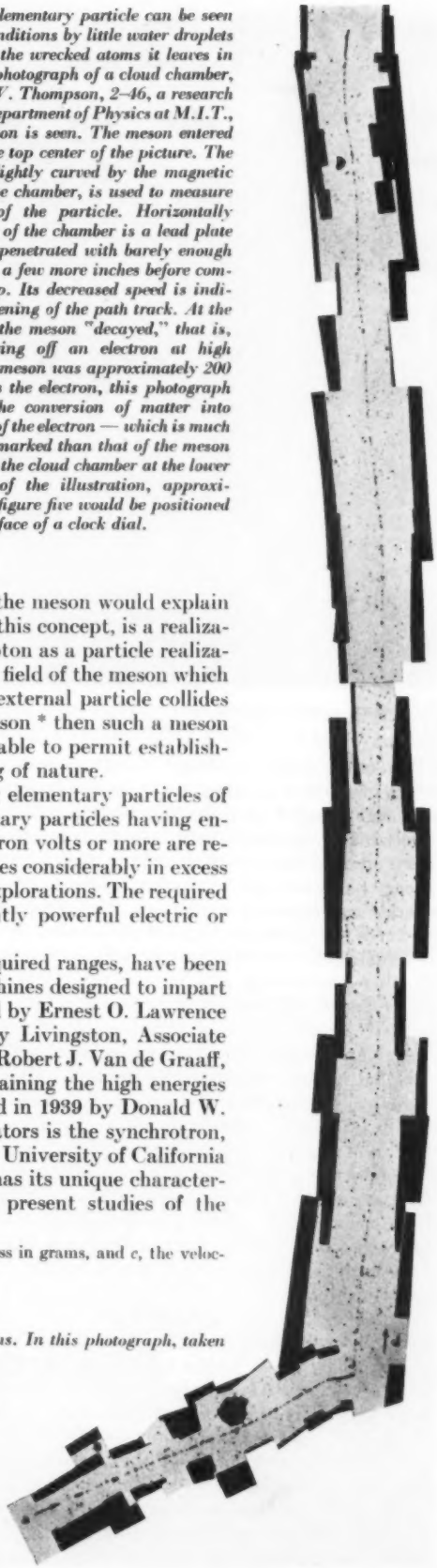
The path of an elementary particle can be seen under suitable conditions by little water droplets that condense on the wrecked atoms it leaves in its path. In this photograph of a cloud chamber, taken by Robert W. Thompson, 2–46, a research associate in the Department of Physics at M.I.T., the path of a meson is seen. The meson entered the chamber at the top center of the picture. The path, which is slightly curved by the magnetic field traversing the chamber, is used to measure the momentum of the particle. Horizontally across the middle of the chamber is a lead plate which the meson penetrated with barely enough energy to proceed a few more inches before coming to a final stop. Its decreased speed is indicated by the thickening of the path track. At the end of its track, the meson "decayed," that is, disintegrated, giving off an electron at high energy. Since the meson was approximately 200 times as heavy as the electron, this photograph is a record of the conversion of matter into energy. The path of the electron — which is much less prominently marked than that of the meson — is seen leaving the cloud chamber at the lower right-hand part of the illustration, approximately where the figure five would be positioned on the face of a clock dial.

theoretical physicist, Hideki Yukawa, in 1935. Yukawa proposed that the meson would explain the attractive forces within the nucleus itself. The meson, according to this concept, is a realization of a mass field (called a meson field), which is analogous to the photon as a particle realization of electromagnetic energy in an electromagnetic field. It is the mass field of the meson which is thought to keep the nucleus of the atom together. If, however, an external particle collides with the nucleus with sufficient energy equivalent to the mass of a meson * then such a meson particle can be freed from the nucleus. Sufficient data are not yet available to permit establishment of a unique theory; this is on the frontier of man's understanding of nature.

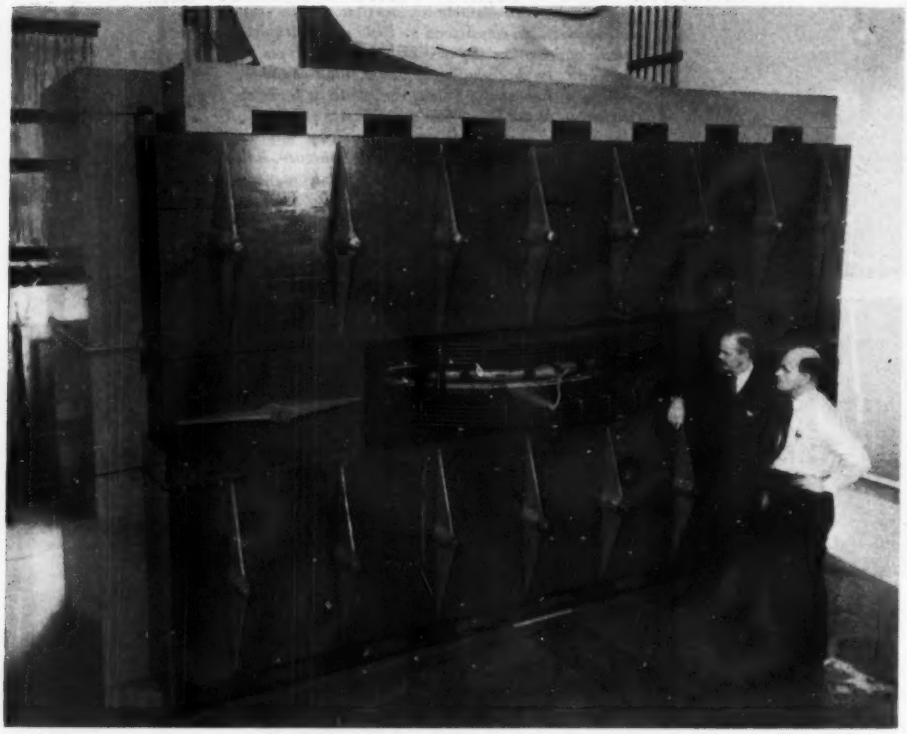
From this discussion it should be evident that means for producing elementary particles of high energy are of tremendous importance in modern science. Elementary particles having energies of from a few hundred thousand electron volts to 20 million electron volts or more are required to investigate the simpler processes of the atomic nucleus. Energies considerably in excess of 20 million electron volts hold forth the most promising fields for new explorations. The required energies can be imparted to electrically charged particles by sufficiently powerful electric or magnetic fields to produce the required accelerations.

Laboratory accelerators, which are able to produce energy in the required ranges, have been developed during the past 20 years. One of the most notable of the machines designed to impart high energy to elementary particles is the cyclotron which was invented by Ernest O. Lawrence of the University of California and his associates, notably M. Stanley Livingston, Associate Professor of Physics at M.I.T. The electrostatic generator, invented by Robert J. Van de Graaff, Associate Professor of Physics at M.I.T., is another mechanism for attaining the high energies required for atomic nuclei studies. Still another is the betatron invented in 1939 by Donald W. Kerst of the University of Illinois. The newest of such particle accelerators is the synchrotron, originally proposed independently in 1945 by Edwin M. McMillan of the University of California and V. Veksler in Russia. Each of these different types of accelerators has its unique characteristics and advantages, and consequently all of them have a place in present studies of the ultimate structure of matter.

* According to the Einstein relation, $E = mc^2$, where E is the energy in ergs, m, the mass in grams, and c, the velocity of light which is 3×10^{10} centimeters per second.



Mesons, protons, and alpha particles leave visible tracks in photographic plate emulsions. In this photograph, taken by C. P. Powell and G. P. S. Occhialini at Bristol University, England, a meson track is seen entering the emulsion at the lower left corner. It proceeds to the right, being continuously slowed down by collisions with the atoms in the emulsions, as is evidenced by the thickening of the path. This meson, known as a π meson comes to rest and disintegrates into another meson, called a μ meson, plus other radiation. The μ meson proceeds up and to the right coming to rest again within the emulsion at the upper right-hand corner. By measuring the length of path, the density of grain darkening, and the scattering in the direction along the path it is possible to deduce that the mass of the π meson is 1.8 times that of the μ meson.



The General Electric betatron accelerates electrons to 100 million electron volts. It is the largest machine of this type in existence. The magnet weighs approximately 130 tons.

To understand the basic operation of the different types of particle accelerators, it is well to recall how elementary charged particles behave under the influence of electric and magnetic fields. In the presence of a constant and uniform electric field, a slowly moving, low-energy particle is uniformly accelerated and its speed and energy consequently increased. With increased energy, however, the apparent mass of the particle increases; this is sometimes referred to as the relativistic mass increase. Further acceleration will increase the speed of such particles up to, but never quite reaching, the velocity of light. Near the speed of light, an electric field can no longer appreciably increase the speed of a charged particle, but the momentum of the particle increases without limit as the apparent mass increases without limit. On the other hand, a constant and uniform magnetic field produces no force on the charged particle unless the particle is moving. For a particle moving in a uniform magnetic field, the resulting force will be at right angles to both the velocity and the magnetic field. For example, a charged particle moving at constant speed perpendicular to a uniform magnetic field will move in a circle corresponding to an acceleration just opposite to centrifugal force. The radius of the circle is proportional to the momentum of the particle. At low speeds, the momentum of the particle is equal to the mass of the particle multiplied by its velocity. At such low speeds, therefore, the time for one orbit is independent of the speed of the particle. In the relativistic range, the momentum is no longer proportional to the velocity of the particle and hence the time per revolution is no longer independent of the velocity of the particle, or its equivalent, the energy of the particle. Different combinations of electric and magnetic fields are employed in the various particle accelerators used in nuclear physics. A magnetic field which varies with time is always accompanied by an induced electric field which can also be used for the acceleration of the charged particles.

The cyclotron uses a large magnet to keep charged particles moving about in concentric circles. It is a characteristic of the cyclotron that the time required for the particle to complete a circular orbit is independent of the energy of the particle. A radio frequency oscillator (which is fundamentally much like a broadcast transmitter) is used in conjunction with the magnet to provide an electric field which gives a sudden acceleration or "kick" to the particle each time it completes a semicircular path. In so doing, it increases the energy (and therefore the speed) of the particle twice in a complete round trip. Because the particles have the same frequency of rotation as that of the oscillator — that is, they are in resonance with the oscillator — the cyclotron is sometimes referred to as a resonance machine. The particle traverses a spiral path of increasing radius, and makes a round trip during one cycle of operation of the oscillator. A limit to the maximum energy of the particle is set by the increase in the relativistic mass of the particle. As the mass of the particle increases, it is no longer able to derive the same acceleration from each "kick." This spoils the resonance condition. The practical limit for cyclotrons is in the neighborhood of 20 million electron volts for positive particles like protons, deuterons, and alpha particles. The energy limit for electrons is well below half a million electron volts, so that the cyclotron is not used to accelerate electrons.

Other equipment to impart high energy to elementary particles uses straight acceleration by direct voltages in the range up to five million volts. It is quite costly to obtain such high voltages by rectifying the output of high-voltage transformers, and therefore other means for obtaining the necessary potentials have been developed. The most notable contribution in this field was the development of the electrostatic generator, known by the name of its inventor — Robert J. Van de Graaff of M.I.T. These static generators can be used for any charged particles. The output of the equipment is characterized by exceedingly good homogeneity of the beam. So far, practical limits and costs have limited the output of these machines to less than five million volts, although a twelve-million volt machine is now under construction at M.I.T. by John G. Trump, '33.

To provide for a controlled source of particles of sufficient energy to make mesons in the laboratory is now

"big game" in electrical engineering and physics. A partial approach was made by the invention of the betatron by Kerst in 1939. The betatron has been used only with electrons, and the largest machine built so far has produced particles of 100 million electron-volts energy. If we accept the present tentative mass of the meson within the nucleus as 360 electron masses, the minimum energy required to produce a free meson is 180 million electron volts, according to the Einstein relation. Hence, the largest betatron now in existence misses the chance to produce mesons by 80 million electron volts. A 300-million electron-volt betatron is now under construction at the University of Illinois, and it is believed that upon completion this machine should be capable of producing mesons easily.

The performance of the betatron is based on electromagnetic induction and the accelerator is identical in principle to the operation of an ordinary alternating-current transformer. Both the betatron and the alternating-current transformer make use of Faraday's law — a time-varying magnetic field is always accompanied by an induced voltage.

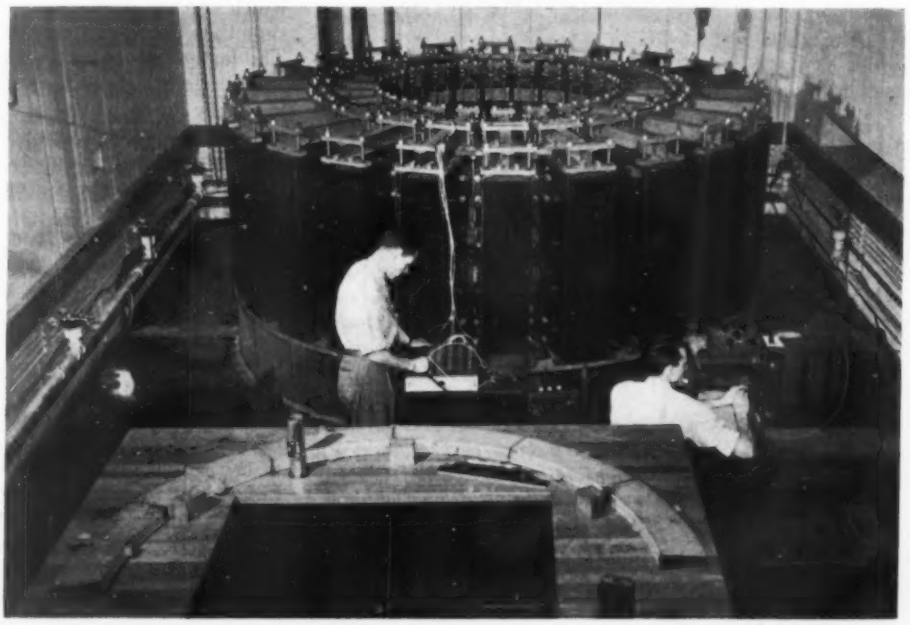
The transformer core (usually called the magnet in a betatron) is made of laminated steel and is excited by alternating current flowing through the primary winding. In the ordinary transformer, the output current flows in a secondary winding which channels the direction of the flow of the electrons. In the betatron, however, the output or secondary current is a beam of electrons flowing in a vacuum. The electron beam is forced to flow into a circular orbit by the strong magnetic field of the magnet. The magnet or transformer core of the betatron serves a dual purpose: it provides the electromotive force and also a focusing force to keep the electrons in a stable circular orbit. It is the twofold purpose of the magnet which establishes a limit to the maximum energy of the particles in the betatron. Because the electrons move at high speed, and are simultaneously accelerated inward to go in circles, they radiate energy in the form of visual light. This radiation, at the higher energies, upsets the balance between the two requirements and limits the practical energy of the betatron to a few hundred million electron volts.

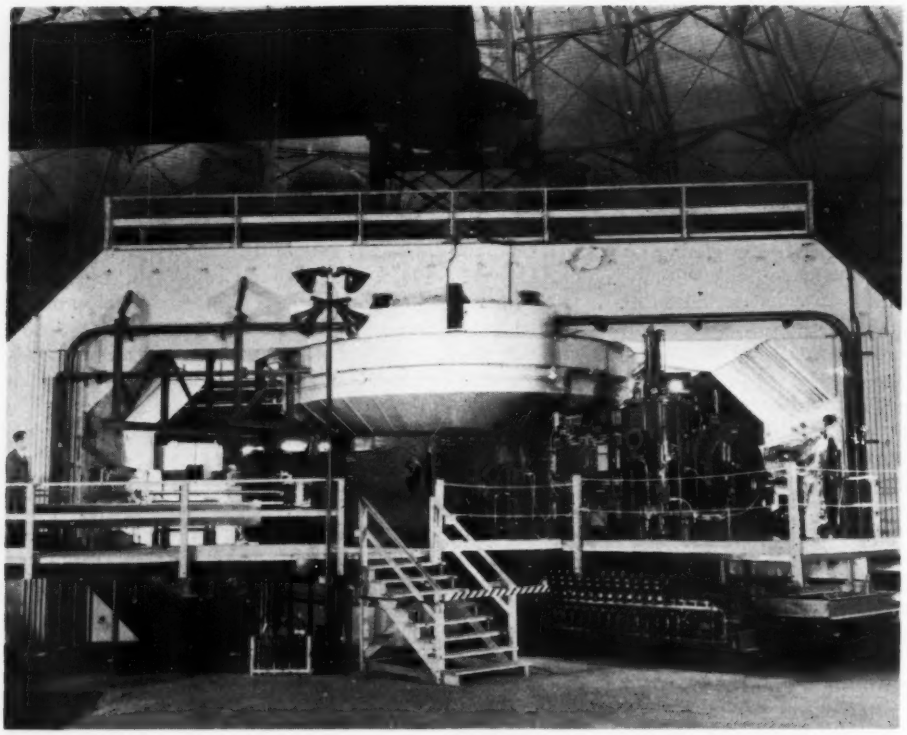
The sequence of operations in a betatron are as follows: (1) by means of a standard electron gun, the electrons are injected into a highly evacuated tube of doughnut shape at about 50,000 volts, immediately after the magnetic field passes through its zero value; (2) the electrons are accelerated by induced electromotive force to the peak value of the machine when the field of the magnet may be, for example, 7,000 gauss, and the energy of the electrons has reached 100 million electron volts; (3) the electrons are forced to spiral inward against a tungsten target by a momentary additional magnetic field. When the electrons strike the tungsten target, their energy is converted into high-energy x-rays which penetrate the walls of the tube.

The most plausible method of achieving artificial energies approaching the primary cosmic rays is embodied in a machine called the synchrotron. Physically, the synchrotron resembles a cross between a cyclotron and a betatron, for it uses radio-frequency power to accelerate the particles, and an alternating current magnet to provide a circular orbit and focusing. Since the forces for accelerating and focusing the beam are independent, the synchrotron has fewer design and operating limitations than the betatron. In its simplest form, as used for accelerating electrons, the synchrotron employs a constant frequency radio-frequency oscillator and accelerates the electrons only after they have nearly reached the velocity of light. In the M.I.T. synchrotron, for example, the electrons are accelerated from an energy of approximately two million electron volts to 300 million electron volts. In this range the electron velocity varies from 98 per cent of the velocity of light to essentially the velocity of light. The electron is brought up to the two-million volt range by betatron action, so that one can think of the betatron here as a two-million electron-volt injection gun for the synchrotron.

The sequence of operation of such a synchrotron is as follows: (1) the electrons are injected at 50,000 volts into a very low magnetic field (8 gauss) exactly as in a betatron; (2) the electrons are accelerated to two million electron volts by electromagnetic induction, the magnetic field increasing with time up to 200 gauss; (3) the radio-frequency voltage is applied across a gap in the orbital

The M.I.T. synchrotron is one of the four largest machines under construction for accelerating electrons. It is designed to accelerate electrons to 300 million electron volts. The synchrotron is a much more efficient machine in the use of iron than a betatron. The synchrotron magnet weighs only 55 tons, while a betatron magnet for the same energy would weigh nearly 1,000 tons.

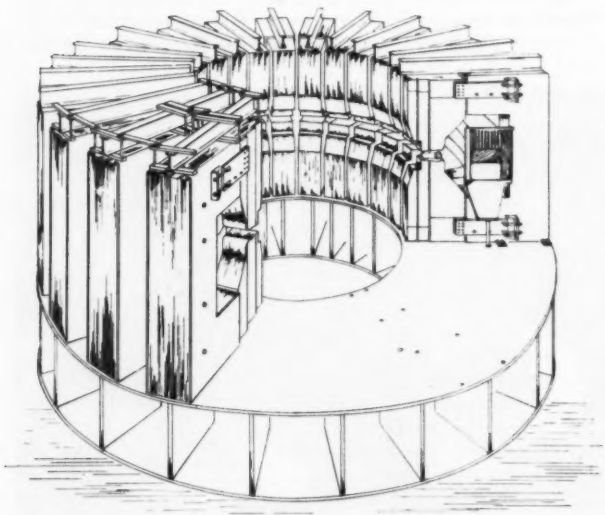




A general view of the giant Berkeley cyclotron, now producing 200-million-electron-volt deuterons and 400 million-electron-volt alpha particles operating as a synchro-cyclotron, taken before the installation of the concrete shielding. In the right foreground, on the truck which moves on rails in the floor, are mounted the round vacuum housing for the rotating condenser, its associated vacuum pump, and behind them the oscillator housing. At the left can be seen the target probe, a shaft entering a port in the main vacuum chamber.

path of the electron (see page 436), and is kept on until the magnetic field has reached its peak value of 10,000 gauss 1/250 second after the beginning of the cycle; (4) the electrons are forced to strike a tungsten target by a momentary disturbance in the magnetic field or by turning off the oscillator. Phase (3) is the synchrotron phase.

In principle, the synchrotron resembles a synchronous motor with the electrons (or protons in a proton synchrotron) acting as the rotor. If the magnetic field of the synchrotron magnet were kept at a constant value, the electrons would keep rotating at an energy value corresponding to the field; the electrons would cross the accelerating voltage gap at the time when the accelerating voltage was zero — or at zero phase, in other words. As the magnetic field increases, the radius of the orbit decreases, and so does the time for a particle to make a round trip. Since the particle then arrives at the gap earlier than that outlined above, it passes the gap (across which the radio-frequency voltage is applied) at such a time that there is an accelerating voltage across this gap. The faster the magnetic field is increased, the greater is this accelerating voltage and hence the greater is the gain in energy for each orbit of the electron. Provided that the radio-frequency voltage across the gap is large enough and the change in magnetic field not too great, the electron cannot get out of step with the accelerating radio-frequency voltage.



The magnet of the M.I.T. synchrotron consists of 24 C-shaped magnets, each magnet weighing over two tons. Each section is 13 inches thick and is made of .014-inch transformer steel. The poles of the magnet face inward. The acceleration tube is placed between the poles of the magnet. The energizing coil is shown on the right through the hole in the C section. The magnet requires 6,000 amperes peak current and a peak voltage of 15,000 volts.

The largest synchrotron now in operation is the 70-million electron-volt machine at the General Electric Company's laboratory at Schenectady, N. Y., but 300-million electron-volt synchrotrons for the acceleration of electrons are being built at M.I.T., the University of California, Purdue University, Cornell University, the University of Michigan, and in England. Proton synchrotrons exceeding the billion electron-volt range are in the design stages at the Brookhaven National Laboratory and at the University of California; and a one and one-half billion-volt machine has been started in England.

The term "synchro-cyclotron" has been applied to another version of the synchrotron in which the magnet is kept at a fixed value and the radio frequency is varied to keep the machine in synchronism (*Concluded on page 452*)

The wood and metal shield, used as the heading for this article, was made in the Hobby Shop by Bartholomew Mandel

By Isaay Stempnitzky

NO man can be considered to be well rounded if his interests are completely locked up in his business or his profession. Some people take their work so seriously that they lose their perspective and sense of humor; others may use their work as a means to escape certain obligations. No matter how satisfying an individual may find his occupation, however, he always has, or should have, some additional energy left to devote to creative activities which are just as essential to his happiness as is a successful business or profession. A nice balance between creative avocational and professional activities is necessary to develop a complete and emotionally wholesome social being.

In a sense, hobbies and avocations are one of the most effective forms of insurance against boredom. During the past few decades there has developed a steadily growing awareness in civilized society of the importance of recreation in general and of hobbies in particular. Before man's ingenuity had developed technology to its present high level, his work often furnished him a means to express his individuality. Today, however, work has lost this creative significance for very many people who seek an activity which will serve their need for self expression in much the same way as pride of workmanship served the need of earlier craftsmen. Hobbies fulfill this requirement.

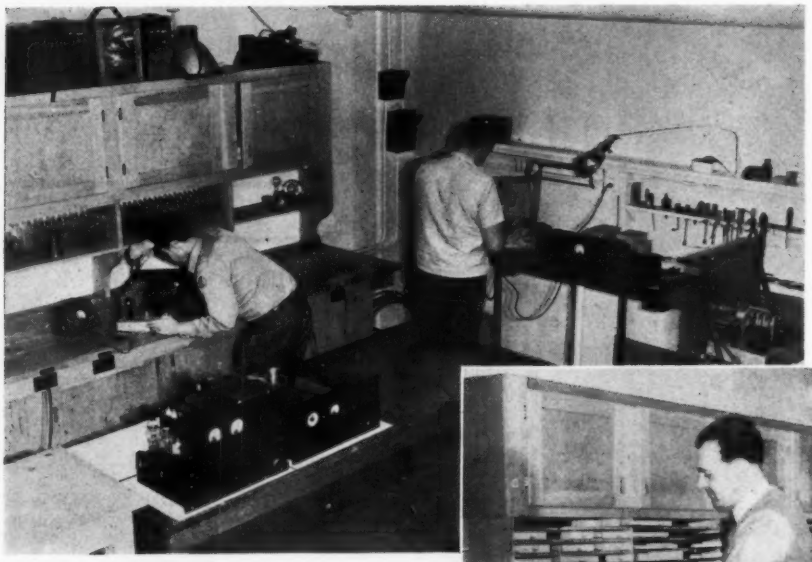
Hobbies serve all manner of purposes for different people, and may satisfy multiform needs in the same individual at various times. Both physically and emotionally, hobbies complement the daily occupation of an individual. They compensate for environmental monotony, satisfy the need for new experiences, and provide escape from reality. Hobbies serve as a means to discharge aggressive drives, satisfy the need which most people have of belonging to a group whose members have common interests, or, alternatively afford excellent sources of solitude for the individual.

It matters not what hobby one chooses, in most cases, but the most beneficial hobbies are probably those which provide a lifelong appeal, and can be taken up at any time. Some persons find satisfaction in binding books, building telescopes, or grinding gems; others, in painting, photography, carpentry, etching, or carving. Still others delight in magic, gardening, or even reading, mathematics, or astronomy. Indeed, in the selection of a hobby, there is no accounting for taste. Recently, the newspapers carried a story about a Chicago butcher who took up whittling after shop hours. He devoted four years in converting a plank of wood 18 feet long and 22 inches wide into a 350-foot chain. Full of pride upon completing the self-assigned task, he wrapped the chain around himself and had photographs made for posterity.

Although the primary value of a hobby lies in the development of personality, frequently it has proved to have appreciable commercial value as well. More than one person has turned a hobby into a means of making a living when economic reverses overtook him. With a population whose average age is increasing, so that more and more persons are able to retire, the outside interests developed through hobbies make the transition to retirement pleasant and something to anticipate rather than to fear.

In the belief that hobbies form an essential part of a well-rounded education and should be part of the normal activities of every individual, the M.I.T. Hobby Shop was established to provide for "all students of the Institute the means for doing such work as they desire in order to make their spare time useful and pleasurable." It thus provides an opportunity for students to develop interesting and useful avocations, even though they may have had no experience in any hobby. In fact, one of the most important functions of the Hobby Shop is to encourage students to participate in avocations which may be new to them. Another important function is to provide students with opportunity to work with their hands, and thus to lend additional practicability to the more theoretical courses which form a major portion of the academic work at M.I.T.

The Hobby Shop is primarily and predominantly an activity for, of, and by M.I.T. students. Under certain conditions however, membership in the Hobby Shop is also open to the M.I.T. staff and Alumni who, as stu-



◀ *Radio and electronics are popular hobbies with many Technology students who derive much satisfaction in building, testing, and using radio receiving and transmitting equipment, recorders, measuring equipment, or any of the many gadgets to which electronics so well adapts itself. In the radio shop, Daniel D. McSwiney, '49, checks the electrical performance of a finished rectifier-power supply while Robert D. McCadden, assistant superintendent of the Hobby Shop, completes the wiring of an audio amplifier.*

A job-printing press and a good stock of type of various sizes and fonts are available for students who are interested in printing as a hobby. Shown practicing this hobby are Eduardo H. Armanino, '48, master craftsman, operating the press, while Richard V. Baum, '48, foreman of the Hobby Shop, makes corrections in type which has been set. In the background is the optics and lapidary room where students may grind and polish lenses, such as those for reflecting telescopes, or may exercise their talents in the grinding and mounting of gems. ▶

dents, were members of the Hobby Shop. Management of the Hobby Shop is entirely by students but full-time craftsmen and a Faculty advisory committee are available to students who may desire instruction or guidance in their projects or in the administration of the Shop.

The M.I.T. Hobby Shop was organized in the fall of 1937 by a group of undergraduates, in co-operation with the Technology Museum Committee under the guidance of Arthur C. Watson who was then its chairman. A room in the basement of Building 2 was set aside for the Hobby Shop, and equipment was donated by many departments of the Institute. The original workshop had a floor area of about 350 square feet and, in addition to the more necessary hand tools, contained a bench lathe, a woodworking lathe, a circular saw, a jig saw, a drill press, and a grinder. By the end of its second term, the Hobby Shop had grown sufficiently to be able to assemble a good-sized exhibit for the Open House activities in the spring of 1938.

During the early growth of the Hobby Shop, many ingenious articles were built for the hobbyists' own use; a few of them fell into the category of co-operative activities, and some projects were even subsequently displayed in the halls of the Institute as a part of permanent exhibits. These projects include a mechanized exhibit of mathematical models built by Edmund B. Hammond, Jr., '40, under the guidance of Professor Raymond D. Douglass, '31, of the Department of Mathematics, an exact replica of the first telephone instrument of Alexander Graham Bell, and a carefully detailed model of a glass factory and one of a pottery factory, both of which are on permanent display. During these early days, the lack of funds did not deter the hobbyists; odd pieces of lumber were transformed into a row of bins for tools and a few odd pieces of worthless pipe showed up later as legs of a shop bench. When an alarm was sounded because of the scarcity of knives, five old hacksaw blades were transformed into most respectable-looking knives of assorted sizes and shapes. In order to provide pleasanter surroundings than those offered by bare walls decorated by pipes, George Y. Yevick, '42, painted a mural which he donated to the Shop.

While devoting a considerable amount of time and effort to the building of the Hobby Shop, the first members found time to make some of the most interesting and unusual projects the Shop has ever seen. One imaginative fellow made a "perpetual motion machine" which almost appeared to disprove the laws of thermodynamics.

During the early part of World War II, the Army Specialized Training Program at the Institute brought a large attendance of enlisted men to the Hobby Shop. Many of them were skilled craftsmen and their work (which included construction of everything from a pair of candlesticks to a full-sized bed) compared very favorably with high-quality commercial products. "I am one of

those people," wrote Jack J. Hinman, 3d, 9–46, Lieutenant Commander, United States Navy, "who finds it relaxing and pleasurable to work with his hands in spare time, as a rest from work on the books. If I had been here long enough to fix up a house, I know the Shop would have been a source of real savings."

The Hobby Shop's contribution to the war effort included the construction of a large number of airplane models which were subsequently used by the armed services in the instruction of airplane recognition. The major project under this category was a relief map (four feet by six feet) of the defense area of Australia, where Allied forces were battling the Japanese. The relief map, made under the guidance of Mr. Watson, was completed in two months and sent to the United States Military Academy at West Point.

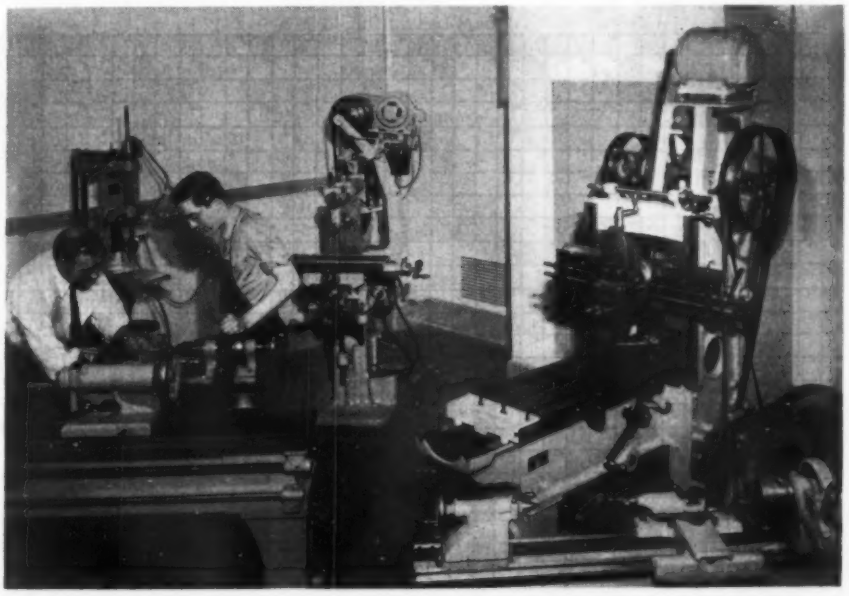
In the fall of 1946, the number of civilian members at the Shop was sufficiently large to begin a new organization. Officers were elected and various committees were set up to study the needs of the various departments of the workshop. Most of the original tools and machinery, which were already used equipment when donated by several departments of the Institute, have been in constant use for nearly 10 years and will be replaced as soon as funds become available. The used equipment donated to the Hobby Shop has proved to be excellent material as projects for reconditioning. A 14-inch Reed lathe, for example, donated by the Machine Tool Laboratory, had to be adapted to the existing facilities at the Shop. Among other things, a new type of drive and speed-changing mechanism was designed and made at the Shop by one of the master craftsmen. An old drill grinder, recently donated by the Mechanical Engineering Department, solved the difficult problem of sharpening tools, after it was completely reconditioned by an enthusiastic hobbyist. Existing machines are constantly being enriched with new and useful attachments — products of the imagination and skill of some of the members. One of the members, for example, has designed, constructed, and installed an unusual type of vacuum machine to recover, filter, and feed the lubricating oil used in the milling machine.

Joseph F. MacAllister, the present superintendent, has been associated with the Hobby Shop since 1942. A highly skilled craftsman himself, Mr. MacAllister has helped many of the Shop members to develop their creative abilities to points of really fine craftsmanship, and by keeping abreast of the activities in the hobby work, he has introduced many new and interesting hobbies. It is interesting to note that more than two thirds of the newcomers do not have the most rudimentary knowledge of the use and care of even the simplest and most common of tools. These students are taught the fundamentals of the use and care of tools before they are permitted to make use of any equipment. Some students who take too seriously the old saying that "all work and no play makes Jack a dull boy" are promptly given a lecture on the true meaning of the adage.

Recently the Institute has allocated additional space for the much needed expansion of the Hobby Shop. Bookbinding, gem grinding, lens making, glass blowing, foundry work, woodworking, and metalworking, all of which were formerly crammed into one room, three bays in size, have now been redistributed, allowing more floor space for each activity. Although the newly allocated room is adequately lighted, the former section of the Shop is very much in need of better lighting, and fluorescent fixtures will be obtained as soon as funds become available.

In spite of limited facilities, the Hobby Shop has seen the completion of many interesting projects. A few of these, such as an arc-welding machine built from an old General Electric pole transformer, and a dielectric-heating machine which not only glues wood but broils hamburgers as well, were made for the membership in general. Individual projects range from printing personal Christmas cards to rebuilding an old Rolls-Royce and even completely furnishing a home. One of the models presented at the recent Fisher Body Contest was made at the Hobby Shop, and it brought to Charles M. Jordan, '49, a prize of $4,000.

Students who use the Hobby Shop are made acquainted with the various machines (*Concluded on page 460*)



The machine shop is ▶ provided with lathes, drill presses, and milling machines for almost any kind of metal work, and some of these are shown here. Under the friendly and able guidance of Joseph F. MacAllister, Hobby Shop superintendent, Richard A. Poirier, '50, learns a few pointers on precision of measurements as applied to lathe work. Although not illustrated, a photographic darkroom, wood-turning and carpentry shop are also available for student use.

Technology Crossword Puzzle

Terms Every M. I. T. Student and Alumnus Know Are Incorporated in a Challenging Crossword Diagram

By John M. Keck

UNDOUBTEDLY many readers of The Review engage in the popular pastime of solving crossword puzzles. For this group an innovation is presented in a crossword puzzle bristling with terms, abbreviations, symbols, and activities which form a part of the life of every student at the Institute. Some terms are as up to date as today's newspapers; others may revive reminiscences of "the Tech on Boylston Street."

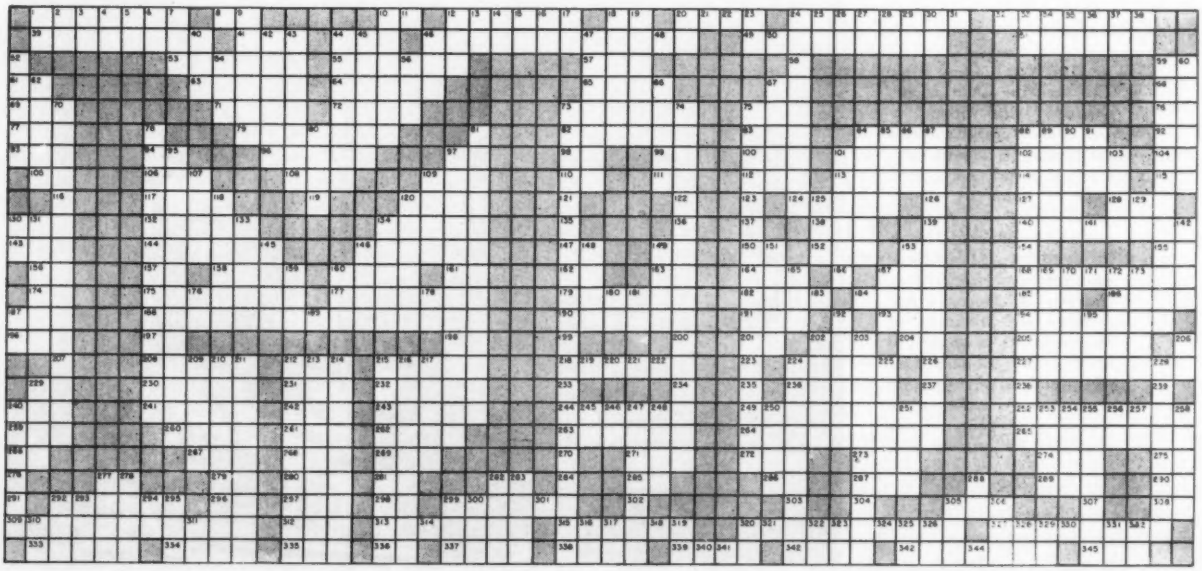
The cult of crossword puzzle addicts includes some diagramless fans who prefer to work out suitable words without the aid of the scaffolding which the crossword diagram affords. For such, the tabulations of vertical and horizontal terms, beginning on pages 445, 454 and 456 may be used without reference to the sketch below.

For perhaps the greater number who prefer to fill in the customary checkerboard diagram, this is presented below. The diagram is of interest to Technology students and Alumni, not only because of the considerable array of M.I.T. terms employed, but also because the diagram includes designs significant in science and engineering. In addition to the initials of a well-known school of technology, the reader will find symbols for the four arithmetic operations, the sign for equality, and the irrational constant, π, which crops up in every branch of science and engineering. Nor are the athletes overlooked; for them is the traditional *T* for Technology.

The puzzle is made up according to most of the standards for crossword puzzles, such as those used in the puzzle pages of the weekly magazine sections of the New York *Times* and *Herald Tribune*. But two deviations from this practice will be found: (1) there are some duplicate words, but this use is justified since a separate and distinctive key or definition appears for each such term; (2) there are some single-letter words, but none are unkeyed, and these are marked with an asterisk (*). Single-letter terms are defined according to general engineering usage; for example, the letter *g* is universally employed to express the acceleration due to the force of gravitational attraction.

Filling in the diagram below should not be too difficult a task, although it will not be quite as easy as the prank one commuter played. If possible, he would select a seat adjacent to a crossword puzzle addict, pull out his paper, and turn to the daily puzzle. Then, as rapidly as he could write, he would fill in the small squares, much to the annoyance of his methodical and much slower neighbor. After a few moments of active pencil work, he would fold up his paper with a beaming air of satisfaction, leaving his neighbor to wonder at his ability in semantics and etymology. Apparently it made no difference to the fast worker that his injected letters made absolutely no sense whatsoever.

Keys to the horizontal words will be found on page 445, whereas the key to words in vertical columns appears on pages 445, 454, and 456. Solution to this puzzle will appear in the July issue of The Review.



HORIZONTAL

1 No Man's Land at M.I.T.
8 Electric current type
10 Customary M.I.T. degree
12 West Indian superstition *re* charms and witchcraft
18 U.S. legally registered symbol (abbr.)
20 M.I.T. Avenue (abbr.)
24 Bright rich color
32 Our subway station
39 Negro tribe in Cameroons
41 Heroic U.S. President's nickname
44 Inc. (French)
46 The drone of our Tech song at a smoker
49 Performed his profession
51 Tech Show's Honorary
52 Boron symbol *
53 Part of eyeball coat
55 Siouan Indians
57 Anarchistic
58 Length unit * (abbr.)
59 Cobalt symbol
61 Paid notice
63 Floats aloft
64 *Re* European thrush
65 Egyptian alloy
67 Rubidium
68 Public secondary school (abbr.)
69 Our undergraduate scientific monthly (abbr.)
71 Prepare for publication
72 U.S. now has 32 (abbr.)
73 Legal term: Inquiry (Lat.)
75 Comparative suffix (var.)
76 American Institute (abbr.)
77 Norwegian masculine first name
78 One thousand *
79 Electric current instrument
81 Our athletic letter award*
82 Remove bottom from a shoe
83 New Britain Industry (abbr.)
84 Lost important body fluid
88 Electric power unit
92 B. & A. (abbr.)
93 Cathode reaction (abbr.)
94 Army Corps (abbr.)
96 Wooden shoe
97 Exclamation of surprise
98 Prefix ad- before "c"
99 Small letters (print.)
100 Street urchin
101 City of Orange Bowl football
102 Tropical palm genus
104 Lithium symbol
105 Sister continent (abbr.)
106 Catch the breath in weeping
108 Negative adverb (Lat.)
109 Penned: Wr- - -
110 Neighboring state to M.I.T.
111 British coin (abbr.)
112 Energy unit
113 Peevish
114 Sweetheart
115 Plural suffix often used
116 Time symbol in formulae *
117 Telephone in Conn.: - - - - Co.
119 New * (abbr.)
120 Conspire
121 Ton * (abbr.)
122 Sulphur symbol *
123 Gravity symbol in formulae *
124 Ethereal salt
126 Fluorine symbol *
127 Untanned calfskin
128 It is (poet.)
130 Greek letter
132 *Re* ancient Athens
134 In poetical harmony
135 One *
136 Our honor mark *
137 Radius symbol in formulae *
138 Weight: in India
139 Direction * (abbr.)
140 Enclose in a globular body
143 Course I adjective (abbr.)
144 Fair booths or stalls
146 Picturesque
147 M.I.T. alumni organization (abbr.)
149 River in Italy
150 Broad thoroughfare (abbr.)
152 Bitter vetch
153 Fourth-year class (abbr.)
154 Right * (abbr.)
155 Pronoun
156 Football position (abbr.)
157 Hydriodic acid (chem.)
158 Mental conception
160 And others (legal abbr.)
161 Course V (profession abbr.)
162 A puffin of Hawaii
163 Side of stage (abbr.)
164 Rule of action
166 Direction * (abbr.)
167 Consumed
168 Tropical tree in muddy places
174 British decoration (abbr.)
175 City in central Spain
177 Xylophone-like musical instrument
179 Trunks of human bodies
182 Hinted
184 Set or clique (Scot.)
185 Time epoch
186 Times preceding events
187 Garden vegetable
188 State of containing more solute than needed for saturation
190 S.A. plant madder family
191 Connective
192 Mark that means failure*
193 Representative (abbr.)
194 Fashioner
196 N.Y.C. subway division
197 French connective
198 Manganese
199 Vanadium *
200 M. — Course II *
201 Lieutenant (abbr.)
202 Kernel of some fruits
204 Silicon
205 By the way (Lat. — Dictum)
206 Phosphorus symbol *
207 Hydrogen symbol *
208 Fabled giant
212 Spread for drying
215 Island off Venezuela
218 Football team
223 Mark of credit *
224 Prizes Hercules won
226 Argon symbol *
227 Clatter noisily again
229 Artificial language
230 Hot (Ital. fem.)
231 Compass point
232 Egg's enclosure
233 Part of abbr. for New England athletic association, combined with 234h, 235h*†
234 Same as 233h
235 Same as 233h
236 Hollow cut or nick
237 B-U: Heat unit *
238 Civil Engineering Course *
239 Uranium symbol *
240 Boston's fish
241 Slight hurried lunch
242 System weights and measures
243 Ring (Sp. Pres. 2d per.)
244 One who ensnares
249 Socks of cotton silk
252 Inhabitants Near East Peninsula
259 Enzyme
260 Abbr.: schedule
261 Here (Lat.)
262 Sufficient (poet.)
263 Caustic base
264 Dire necessity (comp. word)
265 *Re* artificial light
266 Letter addition (abbr.)
267 Child (slang)
268 Compass point
269 Things (Lat.)
270 Capacity measure * (abbr.)
271 Dialect of Siamese
272 Science (abbr.)
273 Metalliferous rock
274 Waterfall
275 Titanium symbol
276 Iodine symbol *
277 2d vars. crew nickname
279 Fall Smoker to start things † (abbr.)
280 Common French ending
281 Thallium symbol
282 Small weight (abbr.)
284 French: there *
285 Indium symbol
286 High tension (abbr.)
287 British coin system (abbr.)
288 Fifty *
289 Holland Commune
290 Cyprinoid fish
291 M.I.T. athletic award *
292 Our mugs of conviviality
296 Course VI (abbr.)
297 Finis (geom.)
298 Midwestern state (abbr.)
299 Track officials
302 161h and this: Course X *
303 Another letter of 237h *
304 Oxygen symbol *
305 Electrified particle
307 Temperature abbr.* (U. S. system)
308 Course I graduate (abbr.)
309 Course XVI major subj.
312 Swiss canton
313 Iroquoian Indians
315 Satiric
320 Trig. functions (pl.)
327 Inspects
333 *Re* sound
334 Newts
335 Latin "is"
336 State, Bismarck capital (abbr.)
337 Portion of
338 Separate fine from coarse
339 White and black color
342 Catch a glimpse of
343 Wider
345 Greek "T"

* Single letter
† M.I.T. special definition

VERTICAL

1 Calcium symbol
2 American common weight (abbr.)
3 No. Jersey community (dial. abbr.)
4 Half of the Bible (abbr.)
5 Language course
6 Sloth
7 Popular national radio system
8 Mark of deficiency*
9 U. S. northern neighbor
10 Amphibious rodent we love
11 Plural suffix*
12 Force (Lat.)
13 Atop of
14 King of Bashan

(*Continued on page 454*)

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Political Arena

THIS spring, as is the perennial custom, Technology Alumni cast ballots for officers of the M.I.T. Alumni Association, for term members of the Corporation, for members of the National Nominating Committee, and for class representatives on the Council.

C. George Dandrow, '22, was elected president of the M.I.T. Alumni Association for the year beginning July 1, 1948, with Orville B. Denison, '11, as vice-president for a two-year term. Hugh S. Ferguson, '23, and Allan Latham, Jr., '30, were elected to the Executive Committee for two-year terms. Term members of the Corporation, elected by the Alumni Association for five-year terms, were: Thomas D'A. Brophy, '16, Raymond H. Blanchard, '17, and Thomas H. West, '22.

Elected to serve on the National Nominating Committee are: Minot R. Edwards, '22, (*District 3*); John S. Williams, Jr., '22, (*District 6*); and Thomas G. Harvey, '28, (*District 7*). Classes whose numerals end in four and nine also elected representatives to the Council; in each case the person nominated was elected since there was but one nominee for each class representative.

Catechizer

ONE hundred and one members and guests were registered in attendance at the 262d meeting of the Alumni Council in the Campus Room of the Graduate House on Monday, April 26, with Raymond H. Blanchard, '17, President of the Alumni Association, in the chair. Thomas H. Pigford, graduate student in Chemical Engineering, was introduced to Council members by Avery A. Ashdown, '24, Associate Professor of Organic Chemistry, who also commented on campus scenes to adorn the Campus Room. Of eight photographs to be hung, those of the University of Cambridge, University of Toronto, and Dartmouth College are already installed.

After acceptance of the minutes of the meeting of March 29, Charles E Locke, '96, Alumni Secretary, stated that, in addition to those previously reported, four alumni and staff members had made visits to five alumni clubs between February 18 and April 23. Changes in class affiliation were made for 26 men who wished to be identified with their original class after studies were interrupted by war service. Nominations for advisory councils were submitted by Professor John B. Wilbur, '26, and a slate of committeemen, presented by the Personnel Committee, was elected. William W. Garth, Jr., '36, Alumni Day chairman, reported that speakers for the symposium "Logistics of Peace" had given definite acceptance and other plans for Alumni Day were progressing smoothly.

President Blanchard then introduced William B. Maley, '48, chairman of the Senior Week Committee, who made an excellent presentation of the program of student activities for the week of graduation. Upon being called on to brief Council members on recent developments at M.I.T., Robert M. Kimball, '33, Administrative Assistant to the President, spoke on the groundbreaking ceremonies for the Charles Hayden Memorial Library; the combined program of study of M.I.T. and several liberal arts colleges in which students receive bachelor's degrees in arts and science for a five-year study; the $70,000 grant from the American Cancer Society; the plans for the May 1 Open House activities; and the work of the M.I.T. student group of the National Student Association which is sponsoring a program of summer study at M.I.T. for 80 foreign students.

President Blanchard then called on Professor Warren K. Lewis, '05, chairman of the Committee on Educational Survey, to outline the work of his committee in making a complete survey of educational methods at the Institute. Dr. Lewis traced the development of engineering education in the United States, giving special emphasis to the changes which have taken place during the past 50 years. Half a century ago, M.I.T. was training about half the engineers and scientists of the country. Today, by contrast, many other schools have entered the technical field and the Institute trains only about one or two per cent. The prestige and facilities for graduate study at M.I.T. have tended to stress the Institute's role in research and in training men for research positions, and this program has been accelerated by the substantial growth of industrial and research laboratories since World War I. Especially from government, there is great pressure to have the Institute continue sponsored research projects. To the extent that research stimulates and advances an atmosphere of intellectual inquiry, it is desirable in the training of students. On the other hand, Dr. Lewis pointed out that the demand for general engineers and scientists continues at a high level, and the best training for such individuals is not necessarily the best for those who will continue research activities.

Employing a catechistical approach, Professor Lewis invited comments from Alumni on the general problems confronting the Committee on Educational Survey and proposed five questions for discussion as follows: (1) To what degree do the Alumni want M.I.T. to undertake changes in its educational program to meet the changing demands for graduates and how rapidly should the changes be made? (2) Why do many Alumni send their sons and grandsons to schools other than M.I.T., particularly for undergraduate work? (3) Does the fact that Alumni do not send their sons to M.I.T. mean that they feel the Institute should become a graduate school only? (4) Since the problems of modern life result so largely from the impact of engineering and science on society, what responsibility should the Institute assume in the training of men to solve them? Should this responsibility be left to the arts colleges and universities? (5) What is the proper place of intellectual discipline at M.I.T.? What is a proper student load? What insistence should there be on continued and sustained educational effort by the student?

In usual reading order: *Edward L. Moreland, '07, Executive Vice-President, and George R. Harrison, Dean of Science, listen to John G. Trump, '33, Associate Professor of Electrical Engineering, enumerating to Arthur T. Lyman, President of the Massachusetts Division of the American Cancer Society, some of the features of a recently designed 2,000,000-volt generator for the production of x-rays for medical research.*

Alumni Day — June 12

EACH year, one day assumes extraordinary importance in the lives of Technology Alumni. On that day — Alumni Day which, this year, will be on June 12 — former students from all parts of the country (and even beyond the borders of the United States) return to Cambridge to renew old acquaintances and to form new ones; to visit the Institute and to note changes since their last visit; to relive old times with a favorite professor or a class buddy.

The Institute will be open at 8:30 for registration of Alumni, Alumnae, and guests in Building 10 overlooking the Great Court. From 9:00 to 12:30 provision has been made for tours of the M.I.T. Buildings, including laboratories, and the new Senior House and Hayden Memorial Library which are now under construction. Rain or shine will make no difference at luncheon which will be served under canvas, in DuPont Court, with special reunion tables for the 50th-(1898) and 25th-(1923) year classes.

In the afternoon, Walker Memorial will be the scene of the symposium "Logistics of Peace." As symposium chairman, Norman J. Padelford, Professor of International Relations at M.I.T., and former adviser to Secretary of State Byrnes, will introduce outstanding speakers. Clarence D. Howe, 07, Canadian Minister of Trade and Commerce, will discuss matters of defense and international political co-operation; Robert T. Haslam, '11, Vice-President of Standard Oil Company of New Jersey, will outline the role of raw material in world peace; and Richard M. Bissell, Jr., Professor of Economics at M.I.T., and Director of Operations, Economic Co-operation Administration, European Recovery Program, will deliver a paper on the economic foundations of a viable peace.

In the evening, at 7:00 P.M., the Hotel Statler in Boston will resound once more to the strains of "A Stein Song," "Take Me Back to Tech!" and other old favorites. Souvenir steins of new design will be initiated into use, of course. President Compton, in fitting conclusion to a memorable occasion, will deliver his annual message to Alumni on the year's progress at M.I.T.

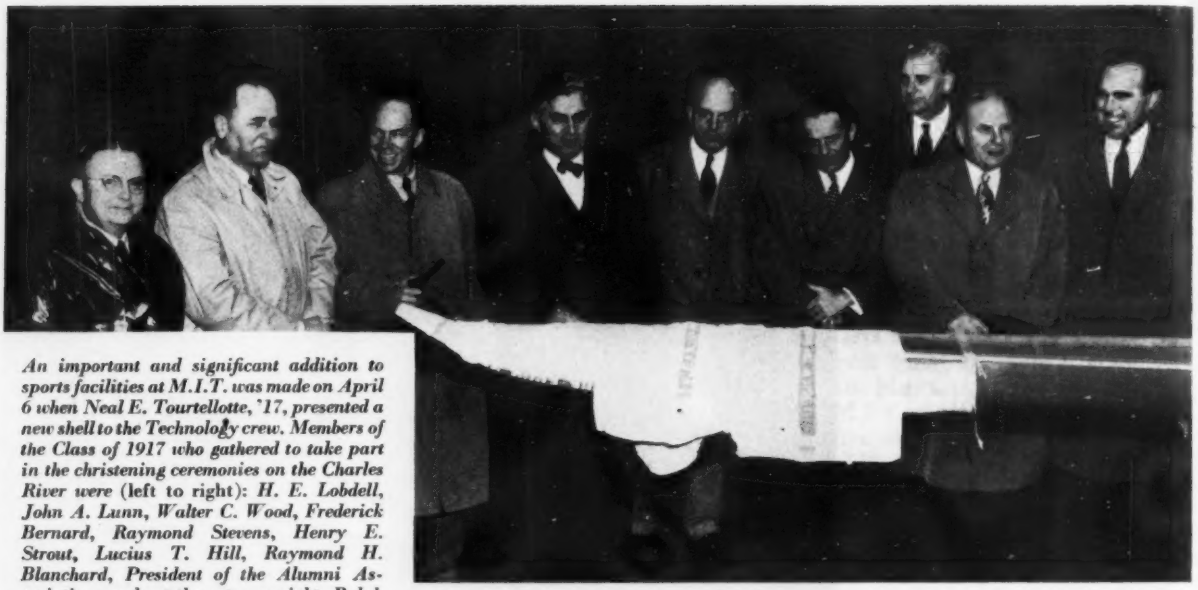
Attack on Cancer

STUDIES of the physical properties of supervoltage x-rays up to 5,000,000 volts will be undertaken at the Institute under a grant from the American Cancer Society, according to a recent announcement by George R. Harrison, Dean of Science.

The grant of $70,000 was presented to M.I.T. by Arthur T. Lyman, President of the Massachusetts Division of the American Cancer Society. It will enable John G. Trump, '33, Associate Professor of Electrical Engineering, who is in charge of the research, to add to the Institute's facilities a compact, flexible 2,000,000-volt generator to study techniques of applying highly localized doses of x-rays deep within the body. The Institute's pioneering program in the development of Van de Graaff-type generators, for producing medical x-rays up to several million volts, was recorded in an article by Dr. Trump in the December, 1947, issue of The Review.

The grant was presented to the Institute in the presence of a group of administration officers and members of the Faculty, including: Harold L. Hazen, '24, Head of the Department of Electrical Engineering; Professor John R. Loofbourow, and Henry S. Bennett, Assistant Professor of Cytology, both of whom are carrying on research in the field of biology; and Dr. Trump whose research will be advanced by the fund. In making the presentation, Mr. Lyman said:

The current campaign of the Massachusetts Division of the American Cancer Society is vital to the support of the type of research Dr. Trump is carrying on, and only through such basic studies can these projects go forward. Science and surgery are working in a concerted effort to determine the cause and cure



An important and significant addition to sports facilities at M.I.T. was made on April 6 when Neal E. Tourtellotte, '17, presented a new shell to the Technology crew. Members of the Class of 1917 who gathered to take part in the christening ceremonies on the Charles River were (left to right): *H. E. Lobdell, John A. Lunn, Walter C. Wood, Frederick Bernard, Raymond Stevens, Henry E. Strout, Lucius T. Hill, Raymond H. Blanchard, President of the Alumni Association, and, at the extreme right, Ralph T. Jope, '28. It came as a surprise to Mr. Jope that the shell was named in his honor, in recognition of his many years of faithful service as secretary of the Advisory Council on Athletics. Mr. Tourtellotte was unable to be present at the christening at which Mr. Lobdell officiated.*

of cancer. No man knows when the cause will be found, but as long as the rapid strides of recent progress are continued, the dawn of the day for the discovery of the cause of cancer will not be too far beyond the horizon. The results of the studies to be undertaken at the Institute, plus new techniques in chemistry and surgery, could possibly end the scourge of cancer, the nation's second greatest cause of death.

In accepting the grant for the Institute, Edward L. Moreland, '07, Executive Vice-President, emphasized the importance of research on the further understanding and control of cancer.

Fellowships for Leaders

DEVELOPMENT, for positions of higher responsibility, of young executives of outstanding capacity, proved managerial ability, and demonstrated awareness of the social effects of industry is the objective of a three-year program of research at the Institute. The educational program for a group of outstanding young business executives is made possible by a grant of $225,000 to M.I.T. by the Alfred P. Sloan Foundation.

Beginning in the summer of 1949, the grant provides for Sloan Fellowships to young business executives who show outstanding promise for leadership in their own companies and for service to our industrial society. The young men selected will come to the Institute on leave of absence from their employing companies for a year of graduate work in the field of business administration and economics, and will have an opportunity to become familiar with the fundamental problems with which business management deals. The new project will be a co-operative activity of the Department of Business and Engineering Administration and the Department of Economics and Social Science. Gerald B. Tallman, Associate Professor of Marketing, has been appointed director of the program.

In announcing the grant, Alfred P. Sloan, Jr., '95, chairman of the board of General Motors, said:

The administrators of business have always played an important role in the health and stability of our industrial society. It is our hope that through this fellowship program the thinking of a group of future business leaders may be broadened to provide to the fullest extent possible a recognition of the interdependence of the industrial and social structure within which they will work and upon which their decisions and contributions will have an effect.

It has long been my feeling that a technical training provides an excellent foundation for a career of industrial leadership, but there needs to be added to the firm discipline of engineering and sciences an exposure to the human organizational problems within business and between business and an industrial society. It is the goal of this fellowship program to select men who have but recently achieved positions of managerial responsibility to provide them with a year's educational experience which will introduce them to many phases of business activities beyond their own past experience and will provide them with an opportunity and stimulation to develop an understanding of their implications.

We believe that Massachusetts Institute of Technology, with its rich technical background and well-developed programs in business management, industrial relations, and economics, is in an unusually favorable position to undertake this educational program. The records of achievement and service made by men who participated in this fellowship program before the war are outstanding and have given us great faith in the productiveness of such an educational experience. It has been most rewarding to the Foundation to have a part in the development of this group of men and to anticipate the continuation and expansion of the program.

Successful Open House

MORE than 30,000 visitors and friends of Technology students visited M.I.T. on Saturday, May 1, in the first Open House exhibit since before World War II. Visitors were able to see numerous mechanisms and methods leading to technological advances, but also had opportunity of observing sports and student life generally at the Institute in a full day's program of events.

BUSINESS IN MOTION

To our Colleagues in American Business . . .

It is an American custom, indeed a tradition, to render public service when one is able to do so. Revere has engaged in such activities, as do all companies in accordance with their abilities and opportunities. We take no particular credit for such work. However, we do feel that it is appropriate to tell you about a new project which may not only be justly described as in the public interest, but which has somewhat of a commercial aspect too.

We refer to the Revere Quality House Institute. This was started by Revere in February. Its object, briefly, is to see what can be done to give home buyers the assurance that they are obtaining value received in materials and construction, and are in addition obtaining those intangibles that add little or nothing to cost but contribute immeasurably to the joy of living — convenience, beauty, adaptation to the site, orientation, privacy, and so on.

To obtain really fine housing in any price range there are two main requisites. One is the establishment of standards of materials and workmanship. The other is professional — the services of architects for original designs and control of quality. Through the Institute we believe both the standards and the services of architects can be made available to builders and buyers of moderate-priced homes. To test out the methods that have been proposed, the Institute plans during 1948 to collaborate in the construction of eight houses in as many sections of the country, each house to be put up by a different architect-builder team.

This is entirely an Institute operation. Revere is building no houses. Though Revere provides the funds to support the Institute through its formative years, it asks of the Institute only that it determine how much quality and comfort can be provided per housing dollar, and how to assure the buyer that he is getting it. In order to avoid any possibility of bias, Revere sought The Architectural Forum as co-sponsor. This is a professional publication deeply interested in housing, and well regarded by both architects and builders. It has assumed the responsibility of the new organization. Revere does not, and will not, control the Institute.

What, then, is Revere getting out of it? For the present, very little. Remember, only about 1% of the cost of the average medium-priced home is represented by the cost of copper and copper alloys required for long, trouble-free service. That includes not only such items as flashing, gutters and downspouts, water and heating lines, termite shields, but also hardware. Obviously, profits from the sale of copper and brass for the eight houses to be built in 1948 by the Institute will be negligible. Taking the long view, however, we believe that through the Institute quality standards will be established for all materials, including metals. The more homes built to those standards, the more copper and brass will be sold by the entire copper and brass industry, including Revere. This will benefit everybody, and especially those who buy and live in houses built to Institute standards, because trouble always costs more than sturdy, long-lived materials. It is our hope that eventually the Institute will become self-sustaining and will need no more financial help. Whereupon Revere will have the satisfaction of having engaged in a worthy endeavor that was also a good investment.

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

☆ ☆ ☆

Executive Offices:

230 Park Avenue, New York 17, N. Y.

CURTIS
"LO-FRICTION" UNIVERSAL JOINT
Sets New "Standards"

NEW LO-FRICTION
CENTER BLOCK
Actual photo shows NEW CURTIS LO-FRICTION Universal Joint at top (driving end) and a Curtis Standard Joint at bottom (driven end) in dynamometer test with load and angle increased beyond safe limits. NOTE: Standard joint shows excessive heating — approaching failure — while NEW LO-FRICTION joint ran cool and handled overload successfully.

FRICTION — The bug-a-boo in offset drives for power transmissions has been greatly reduced, effectively, yet simply, in this NEW CURTIS LO-FRICTION UNIVERSAL JOINT now available for industrial applications.

Note that two (2) grooves on each of the four (4) bearing surfaces of the center block break each surface into four smaller areas making sixteen bearing faces. By reducing the size of frictional areas, wear is more evenly distributed, lubrication is transmitted more effectively, and friction heat, or kinetic energy, is dissipated, thus increasing joint life and efficiency tremendously.

After many tests, all resulting in the same answer, Curtis has made patent application and is now ready to supply this new LO-FRICTION industrial universal joint in sizes from 1¼" up, either single or double, or in special joints made to your specifications.

Write Dept. B-5

CURTIS UNIVERSAL JOINT CO. INC. SPRINGFIELD MASS.

THE TREND OF AFFAIRS

(*Concluded from page 428*)

exposed, the survivors being permitted to propagate. After 14 generations, this elite corps had more than twice the resistance to DDT of regular stock, the average mortality for unselected flies being 69 per cent, and for the specially bred stock, 34 per cent.

As long ago as 1922 it was noticed that red-scale insects, which had acquired some degree of resistance to hydrocyanic gas, were also more resistant than usual to methyl bromide, ethylene oxide, and a number of other substances not usually classified as nutritious. Similarly, the house flies selected only for their indifference to DDT required about twice as much of several poisons, such as chlordane, rotenone, and pyrethrin — plus five per cent piperonyl cyclonene to achieve the same mortality rates as ordinary strains. The implication, of course, is that similar results may eventually occur under natural conditions, if they are not already under way.

Resistance to poisons is no novelty in nature, being found also among mammals, reptiles, and fish. Some types of constrictor snakes feed on fanged snakes without injury, and a still more remarkable case is a Brazilian skunk which preys on the fer-de-lance and is indifferent to its otherwise deadly venom.

While not involving poisons, there are many examples in agriculture of how selection and mutation can upset man's carefully arranged balance between plants and their diseases. Stem rust of wheat is caused by a fungus known as *Puccinia graminis tricici*. But closer examination reveals that this species is composed of a large and changing number of races. As of 1947, 189 races had been described, but the population shifts. Old races sometimes disappear from the scene, or may change their identifying characteristics, and new races will evolve.

Because of its apparent resistance to stem rust, the variety of spring wheat known as Ceres became popular in the middle 1920's and soon was planted to most of the wheat acreage in the Dakotas, Minnesota, and parts of Canada. About two years after it was introduced, a new race of stem rust (Race 56) was found in Nebraska and Iowa, and within six years it had become the most frequently found type. But the Ceres wheat, although growing well in the presence of the stem-rust races prevalent at the time of its introduction, suffered heavily in the epidemics of 1935 and 1937. The next widely used spring wheat used in the Great Plains area was Thatcher, introduced in 1934. It stood up well during the 1935 epidemic, a factor which gained it rapid favor. By 1939 it was being grown on an estimated 14,500,000 acres in the United States. By 1944, however, the acreage had been reduced to about 4,500,000, for while resistant to stem rust, Thatcher is susceptible to leaf rust. Many other varieties have been tried since, each with its distinctive inbred resistances to disease, but all suffering from the difficulty that they can be selected to withstand only diseases already in existence. Although the agricultural research stations are now considering new and emerging strains of fungi, as well as those dominant in the fields at the moment, the most that can be reasonably hoped for is that we shall obtain a longer head start against the diseases of the future.

Split 1 microampere in half

each half drives this

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*SENSITROL RELAY

MODEL 705 TYPE N

Provides positive control at levels as low as ½ microampere. Operates direct from photocells, thermocouples, resistance bulbs, or any suitable electrical circuit. Non-chattering magnetic contacts handle up to 10 watts at 120 volts.

It will pay you to submit your relay problems to WESTON. The WESTON line includes sensitive relays of many types, including the "high sensitivity —high contact capacity" Model 705. Time delay and power relays designed to operate from sensitive relay contacts also available. For engineering cooperation consult our representatives, or write ... Weston Electrical Instrument Corporation, 617 Frelinghuysen Avenue, Newark 5, New Jersey.

**SENSITROL*—A registered trade-mark designating the contact-making instruments and relays manufactured exclusively by the Weston Electrical Instrument Corporation.

WESTON *Instruments*

ALBANY · ATLANTA · BOSTON · BUFFALO · CHARLOTTE · CHICAGO · CINCINNATI · CLEVELAND · DALLAS · DENVER · DETROIT · JACKSONVILLE · KNOXVILLE · LITTLE ROCK · LOS ANGELES · MERIDEN · MINNEAPOLIS · NEWARK
NEW ORLEANS · NEW YORK · PHILADELPHIA · PHOENIX · PITTSBURGH · ROCHESTER · SAN FRANCISCO · SEATTLE · ST. LOUIS · SYRACUSE · IN CANADA, NORTHERN ELECTRIC CO., LTD., POWERLITE DEVICES, LTD.

ARTIFICIAL COSMIC RADIATION

(*Concluded from page 440*)

as the mass of the particle (proton, deuteron, or alpha particle) increases. In a sense, the synchro-cyclotron is a half-breed between the cyclotron and the synchrotron. A large number of such machines are now under construction, covering the range of from 100 to nearly 300 million electron volts.

The 300-million electron-volt synchrotron now nearing completion at M.I.T. is the highest energy machine now in existence. It can accelerate electrons up to 300 million electron volts where the mass of the electrons has increased 600 times. When the electrons impinge on the tungsten target, x-rays of all energies up to the 300-million electron volts are formed and emerge in a very narrow cone of less than half a degree. Each pulse of x-rays lasts for less than a millionth of a second.

To produce these high-energy particles, a 55-ton magnet is required. This is a particularly costly magnet and difficult to build, for it must be made entirely of transformer steel, each sheet of which is only 0.014 of an inch thick. To supply energy to the magnet requires a large capacitor bank and an electronic switch. The capacitor stores the energy obtained from the power mains until it is released, by the electron switch, to the magnet. The capacitor for the M.I.T. synchrotron is one of the largest in the world, and is rated at 33,000 kilovolt-amperes, or 800 microfarads at 15,000 volts. A single cycle of current (6,000 amperes) flows at a peak voltage of 15,000 volts. The circulating power in the magnet is, therefore, nearly 100 million volt-amperes, or equal to the power of 2,000 broadcasting stations of 50 kilowatts each. The electrons are accelerated in a specially built vacuum tube made of high-quality steatite, developed by William M. Shakespeare, Jr., '42, at M.I.T., and having a diameter of about eight feet. The cost of the installation is approximately $500,000. The development required a scientific staff of 10 physicists and engineers over a period of two years. The senior men on the M.I.T. synchrotron were: J. Earl Thomas, Jr., Assistant Professor of Electrical Engineering, and Joe S. Chark, '37, Reginald V. Harris, Isaac G. Swope, '27, Philip A. Stowell — all of the Division of Industrial Coöperation. The project was supported by the Office of Naval Research.

It is too early to predict what the new superaccelerators will do. They represent the first effort by man to reach artificially into the energy levels of uranium fission and the creation of mesons. By controlling the source of the particles and their energy, and by having available much higher numbers of particles than were available in natural cosmic radiation, it is hoped to study in detail the behavior of the nucleus and of mesons in these high-energy ranges, and to gain, thereby, experimental knowledge on which to extend our understanding of the structure of the universe. But even with these new machines, man has still a factor of a billion to go before he can compete with nature. Homemade cosmic rays will, therefore, continue to remain but puny efforts, so far as peak energy is concerned, but they will undoubtedly contribute greatly to our knowledge because of the control which the experimenter has over them.

TRADE MARK

ESTABLISHED 1915

Sign of a Great Line of
Materials Handling Equipment
for 33 Years

Multiply your Manpower, Speed up Production, Cut Overhead, and Save Money with Lewis-Shepard Power Fork Trucks, "JackLift," "JackStacker," and "JackTractor," Power Model Trucks, Hydraulic and Mechanical Hand Lift Trucks, "JackLift" Trucks, Pallet Trucks, Pallet Stackers, Portable Elevators, Cranes, Floor Trucks, Skids, and Racks.

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PRODUCTS INC.
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REPRESENTATIVES IN PRINCIPAL CITIES CONSULT YOUR PHONE DIRECTORY

THE GLUE THAT BINDS NOW DRIES IN *Seconds!*

Remember back when gluing wood was a sticky job and hours were required for the glue to "set"?

Modern electrical production methods have changed that job, too. The "heatless heat" of high-frequency radio waves now dries the glue and bonds the wood in seconds. "Edge-gluing" on a conveyor line basis turns waste wood pieces into valuable furniture.

As shown here, for example, boards 48" long by 38" wide by 1" thick can be made up of 15 or 20 scrap pieces—and glued in 30 seconds, ready for conversion into fine cabinets. Time and space for storage in clamps is done away with—variations in clamping pressure and drying conditions are eliminated—up to 50 per cent savings in glue are effected—and three semi-skilled men can produce what six produced before.

Westinghouse Radio-Frequency Heating offers savings in other fields, too. Plywood now can be made to almost unlimited thicknesses, timber arches are easily fabricated, and cabinet or other wood-joining problems are handled with ease.

A complete line of Westinghouse Radio-Frequency Equipment for both dielectric and induction heating is now available. For more information about how and where radio-frequency heating can be applied in your plant, write on your letterhead to Westinghouse Electric Corp., Dept. T, P. O. Box 868, Pittsburgh 30, Penna. J-85004

INVESTIGATE!

Radio-Frequency Heating is just one of many new or improved electrical techniques for producing faster, cheaper, better. Westinghouse engineers can quickly give you salient facts on others applicable to your industry, including the following:

- Electric Furnace Brazing
- Resistance Welding
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Write or phone your nearest Westinghouse office for details.

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MORE PRODUCTIVE POWER FOR INDUSTRY

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1 **Precision Electric Heat Treat Furnaces** *(Laboratory and Industrial)*

2 **Surges Dry Type Air Cooled Transformers** *(to 1000 KVA)*

3 **Constant Current Regulators** *(Static Type)*

1 Hevi Duty Precision Electric Heat Treating furnaces are built in a large variety of types and sizes — for many heat treating operations — with temperature ranges to 2500° F (1371°C). They are standard production equipment in many national industrial plants.

2 Surges quality dry type air cooled transformers with or without tap changing switches as well as special transformers for special requirements.

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Harold E. Koch '22 President

Elton E. Staples '26 District Mgr., Cleveland

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HEVI DUTY

HEAT TREATING FURNACES • ELECTRIC EXCLUSIVELY
DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS
MILWAUKEE 1 WISCONSIN

TECHNOLOGY CROSSWORD PUZZLE

(Continued from page 445)

15 Latin "of"
16 Gold (heraldic)
17 Bone
18 Required for M.I.T. degree
19 Former Mexican president
20 Mountain (abbr.)
21 English article*
22 Baseball position (abbr.)
23 Language course
24 We write 39 after this†
25 Another electric current
26 Right (abbr.)
27 Prefix: two or twice
28 Adj. suffix denoting "of"
29 Six states including Mass. (abbr.)
30 Current years era (abbr.)
31 Mark means "be careful"*
32 Potassium symbol*
33 Printer's measure
34 Sodium symbol
35 Day's sight (abbr.)
36 Water (Lat. abbr.)
37 Lutecium symbol
38 French article
40 Dawn goddess (Gr. myth.)
42 Provides with edge
43 Gracious donor of present M.I.T. buildings
44 Our honored chief executive
45 Mohammedan caravansary
46 A pouch
47 To crush (var.)
48 Nitrogen symbol*
50 Royal* (British abbr.)
52 Musical Clubs Key Honorary
54 Spawn
56 English possessive
59 Gives M.I.T. its beautiful water front
60 Senior Honorary
62 Takes out (print.)
66 Parts of a cent
67 To latch again
70 Electric battery terminal
73 Important chemistry course
74 Undergraduate writes this for Masque
75 Chief sophomore mathematics course
78 State with fishhook cape
80 Very black
81 Chronological record of our student newspaper
84 Stingers
85 Den
86 Electric voltage term
87 What the Frosh did to get "dx"
88 Student Activities Building
89 In control
90 Degrees F. or C. (abbr.)
91 Technology Y.M.C.A.
95 Alumni Association welcomes these for M.I.T. bequest
97 Precept formulated to give victory over Japanese
101 Joiners
103 Anthology (abbr.)
107 Greek "B"
109 Organic chem. suffix
118 Fearful of danger (Fr.)
120 Illuminated beforehand
125 Compass point
129 That is (Lat. abbr.)
130 Percentum (abbr.)
131 White metal for coins
133 Large pine family tree
134 Brazilian sunfish
141 Mark, still passing*
142 Summers (French)
145 Japanese coins
146 Celestial body
148 Tech's student store
149 Malay boat
151 Boast or exult
153 Tech men at a dance *sans femmes*
159 King of Judah
160 Ostrich-like bird
165 Marry
167 Wing
169 Clad informally
170 Lowest point
171 Weight* (chem. abbr.)
172 To rent again
173 Outwardly manifest
176 East Prussia (abbr.)
178 Note of the scale
180 About or concerning
181 State in the cotton area (abbr.)
183 Diameter symbol*
184 Carbon symbol*
187 3.14159 . . .
189 Temperature symbol*
192 Strainer (chem.)
195 Greek letter
202 English dramatist (1786–1872)
203 Arts of industries and manufactures†
206 Hebrew letter
209 Tech team, usually good
210 Course IV graduate
211 Bareness
212 M.I.T. annual yearbook
213 Tech Alumni general professional title (pl.)

(Concluded on page 456)

Illustration shows how Webster Type WI Radiation (indicated by arrows) is installed around skylight

Warm Spot in January Cold Wave

Hundreds of *formerly* "hard-to-heat" buildings . . . places that used to be cold even in normal winter weather . . . were oases of warm comfort during the January-February cold wave, thanks to post-war Webster Type WI Extended Surface Radiation for hot water and two-pipe steam heating service.

Webster Type WI Radiation can be put where the heat is needed —along the wall, close to the floor, behind benches, and in a continuous line in overhead locations such as skylights in which it was the former practice to use pipe coils.

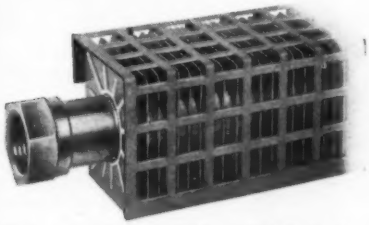
Using modern materials, copper tubing and aluminum fins, Type WI Radiation provides better than a square foot of heating surface for each ½ lb. of weight.

Take steps now while the memory of your cold weather difficulties is fresh in mind. See if Webster Type WI Radiation can be used to turn your cold spots into areas of next winter comfort. Good delivery now.

WARREN WEBSTER & CO., Camden, N. J.
Representatives in Principal Cities :: Est. 1888 :: *In Canada: Darling Bros., Limited, Montreal*

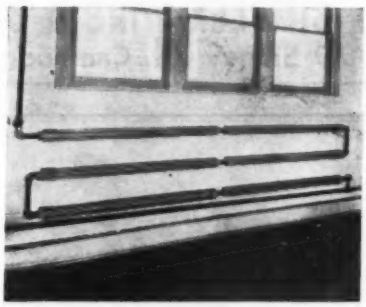
Webster HEATING

Wide Flexibility To Meet Varying Installation Requirements

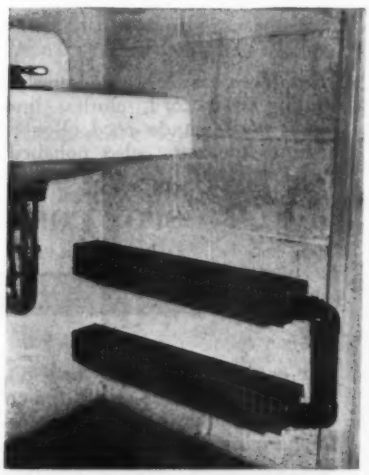


End view of Webster Type WI Radiation

Installation of Webster Type WI Radiation in Gardener's Cottage—hot water heating.



Three rows of Webster Type WI Radiation are sometimes used — View showing vacuum or vapor system installation.



Webster WI Radiation used under basin where vertical wall space is limited—hot water heating.

SIMPLEX - TIREX
ELECTRIC WELDING CABLES

Here's real welding-wise construction! It gives you a cable that's both flexible and tough. It assures you of savings in time, labor, and money on electric welding work.

Extreme flexibility is obtained by making conductors of many threadlike copper wires closely stranded together. It reduces drag and wrist fatigue and contributes to fast, efficient welding even in cramped locations.

Clean stripping is facilitated by a separator of soft cotton braid which does not bind the conductors nor hamper their flexibility.

Resistance to abrasion, moisture, grease, oil, and acids is furnished by a "cured-in-lead" jacket of Selenium Neoprene Armor. The jacket is not easily cut, will not support combustion, and provides insulation with essential electrical stability.

SIMPLEX WIRE & CABLE CO.
79 Sidney St., Cambridge 39, Mass.

Reg. U. S. Pat. Off.

Samson Cordage Works

Boston 10, Mass.

Manufacturers of braided cords of all kinds, including sash cord, clothes line, trolley cord, signal cord, shade cord, Venetian blind cord, awning line, etc., also polished cotton twines and specialties.

SPOT CORD

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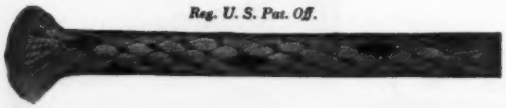


Our extra quality sash cord, distinguished at a glance by our trade-mark, the colored spots. Especially well known as the most durable material for hanging windows, for which use it has been specified by architects for more than half a century.

TECHNOLOGY CROSSWORD PUZZLE

(*Concluded from page 454*)

214 Drops down (Lat. legal form)
215 Affirming statement
216 Valley area of French river
217 B----- Aires (Sp. ending)
219 Latin* (abbr.)
220 640 course — one letter* (combined with 222v, 314v)
221 Five*
222 640 course — another letter* (combined with 220v, 314v)
224 An established order†
225 They fit irons on horses
228 Maniacs
229 Director T.C.A.
240 Per — ,: each
245 Org. chem. alcohol termination
246 Satisfactory (colloq.)
247 Standing out prominently
248 Eagerness for action
250 Irritation of the skin
251 Plant's reproductive ovule
253 A canon
254 Unites with a base to form a salt
255 Profit or advantage
256 Iridium symbol
257 English article
258 Slip off smoothly
277 Glass center Switzerland
278 Glass container (chem.)
282 Persian poet, first name
283 Agreeable interest
288 Behold
292 Theater sign: full house
293 Weight measure as for coal
294 Greek letter
295 Saint (French abbr.)
299 End of a tapering object
300 Mountain belt state (abbr.)
301 Transportation system abbr. — one letter*
305 Prefix meaning equal
306 Man's nickname
310 Latin connective
311 Provided (conjunction)
314 To finish 220v and 222v*
316 Another neighboring state (abbr.)
317 Belonging to
318 Part of abbr. for national collegiate athletic body*† (combined with 184v, 233h, 234h, 341v, 344v)
319 Metric weight (abbr.)
320 Suffix of condition or quality
321 Zero*
322 Arsenic symbol
323 Notary Public (abbr.)
324 601 course* (abbr.)
325 Note well (Lat. abbr.)
326 Alumni magazine (abbr.)
328 Xenon symbol
329 Land measure 119.6 sq. yds.
330 Abbr. for student athletic governing body*† (combined with 318v, 291h, 341v, 344v)
331 Our continent (abbr.)
332 Europium symbol
340 Other letter* 301v abbr.*
341 Same as 330*† (combined with 330v, 318v, 291h, 344v)
344 Same as 330v*† (combined with 330v, 318v, 291h, 341v)

WHAT IS DEMOCRACY?

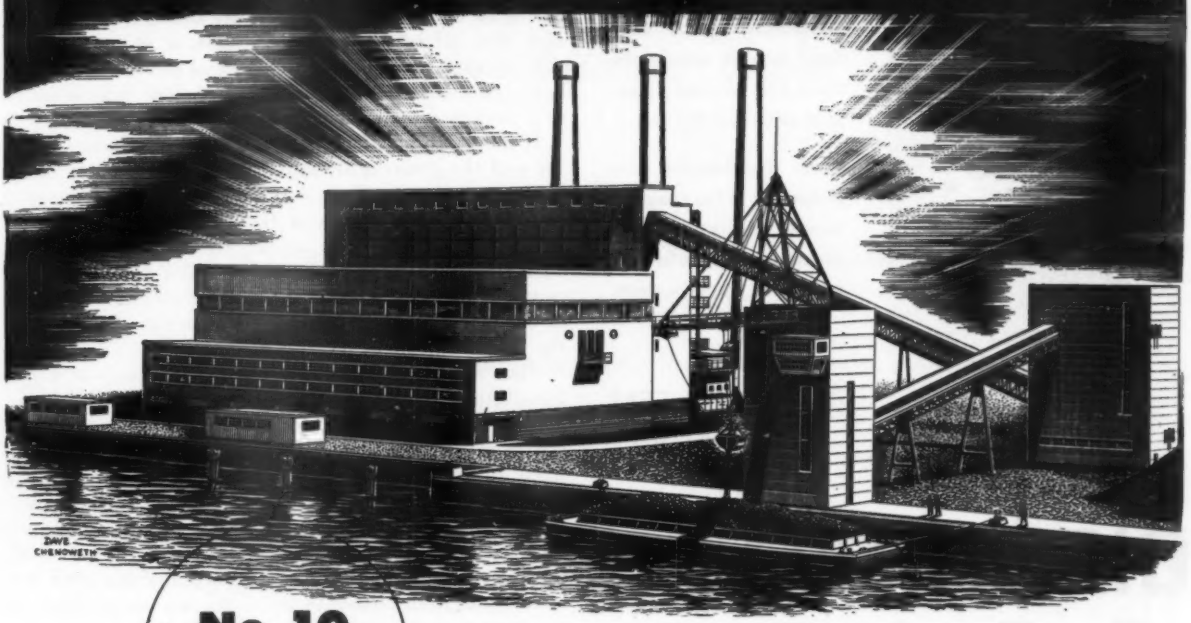
(*Continued from page 434*)

Under conditions of such chaotic change, any single plan is almost certain to be wrong. The only way to increase the chance of success is to have several plans, so that if one fails, another may succeed. The greatest chance of success occurs when each individual makes his own plan. This is the reason for individual liberty and the reason why individual liberty should be taken as the central principle of democracy.

This does not mean that the individual is to have freedom in everything. It is imperative that a sufficient amount of self-discipline be accepted by those who would enjoy the blessings of liberty. Nor does individual liberty mean that we are justified in confusing liberty with license, as happens not infrequently. In some cases, it is necessary that all act alike, and in such instances, complete freedom to follow individual whim is not tolerable.

(*Continued on page 458*)

History-making power stations



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WHAT IS DEMOCRACY?

(*Continued from page 456*)

For example, all must drive on the right, or all on the left, along the highways, and the majority should decide which rule is to be adopted. But in other cases, it is not necessary that all act alike. For example, it is not necessary that all pay taxes for the support of government-owned industries. In a democracy based on true individual liberty such payments would be optional.

It is not an accident that the highest standard of living and the greatest amount of individual liberty should both occur in the United States. Of course some economists think the wealth of the United States is due to natural resources. But according to that argument "Brazil would have more automobiles than any other country. For Brazil has vast potential oil lands, and some of the world's richest deposits of iron ore. Brazil is also the original home of natural rubber." [12]

Thus natural resources are not the sole basis of wealth. In addition, there must be economic liberty. Now liberty is not a privilege each of us wants for his own satisfaction, but is rather the basis for an ever expanding improvement of human welfare. When I was a boy, electric lights and power were being developed. I was greatly interested, and had complete liberty to go into the business and perhaps become a power magnate myself. I did nothing, but Thomas Edison and men of his type went ahead, and in my home today, there are better lights and power than my ancestors ever dreamed of. A little later, the automobile was being considered. Again, I was interested, and might have developed a billion-dollar enterprise myself. Again, I did nothing. Henry Ford and others developed the automobile, and today my modest car is a better vehicle of transportation than was owned by any king in history before my time. Thus, all my life, liberty has meant to me that other people were permitted to do for me things I had neither time nor ability to do for myself. If the liberty of any one of a dozen nations had been given to me, and if to others in this country had been given that liberty of the United States, I should never have known the difference.

And of the many freedoms enjoyed in America, probably the one that has meant most to me is freedom from excessive taxation. Not that my taxes ever amounted to much, my income was too small. But under the lower taxes of this country, men like Henry Ford could build great industries in a single lifetime, and the benefits of those industries could therefore come to me, instead of being reserved for my children or grandchildren, as undoubtedly would have been the case had I lived elsewhere, where opportunity for the individual was restricted.

This more rapid progress is characteristic of individual liberty. Advances come in other nations, but first they come in those nations where there is greatest freedom to exercise personal initiative. This is not only because people accomplish more where there is less hindrance, but also because the ablest people are attracted to places where the opportunities are greatest. We are, therefore, justified in concluding that the form of democracy which provides greatest individual liberty will always produce greatest progress, and, since the strength of a nation is measured mainly by new things, products, and ideas, that this type of democracy will ultimately prevail.

(*Concluded on page 460*)

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WHAT IS DEMOCRACY?

(*Concluded from page 458*)

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M.I.T. HOBBY SHOP

(*Concluded from page 443*)

which are available for their use, and are also required to abide by certain rules which have been established for their safety. Any member of the student body is eligible to become an ordinary member of the Hobby Shop. Those who demonstrate an enthusiasm and willingness to further the objectives of the Hobby Shop may be elected journeymen after having been an ordinary member for at least one term. After at least another term, journeymen may be elected to master-craftsmen membership. Master craftsmen are entitled to all rights and privileges of the Hobby Shop, including election to the position of foreman, who is responsible for the safe and proper conduct of the workshop. The Hobby Shop is open to master craftsmen at any time, provided that at least two members are in the Shop; at no time is the Shop open to a single individual. Officers of the Hobby Shop include: a student foreman, assistant foreman, secretary, and treasurer, who are responsible for the management of the Hobby Shop.

The Hobby Shop is also open to members of the staff and to Alumni upon application and payment of annual dues of $3.00, except that alumni membership is restricted to former Shop members. In thus opening the membership to others beyond full-time students at the Institute, it is understood that the facilities of the Shop are primarily for students; other members are expected to recognize the preferential status of students. Since the *raison d'être* of the Hobby Shop is recreational, projects are expected to be of the student's own choice and initiative rather than the "assigned" type or theses for which the student is expected to make use of the departmental shops.

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THE SHADOWS OF SCIENCE

(*Continued from page 432*)

new cyclotron will travel 100 miles in one one-thousandths of a second from source to target, at a speed eight-tenths the velocity of light, or about 150,000 miles per second. At this speed their mass, under the laws of relativity, will increase about 50 per cent. The radio-frequencies by which they will be speeded up will therefore have to be modulated through frequency modulation over a frequency range of 28 to 17 megacycles per second. In this manner resonant frequency is maintained in synchronization with the resonant frequency of the flying protons."

"Historically," says White,[11] "a study of electric discharges through gases and the discovery of the electron mark the beginning of a new branch of physical science called 'modern physics.' " Credit for naming the electron appears to go to Dr. G. Johnstone Stoney of Dublin.[12] Stoney was not the first to believe in the atomic nature of electricity; Benjamin Franklin had suspected it, and Faraday had presented experimental evidence with his work on electrolysis. Whatever the value of Stoney's calculations on the average charge carried by an ion in solution, his reasoning was correct and only a crude value of Avogadro's number — the number of molecules in a chemical volume, or 22.4 liters — stood in the way of arriving at a more precise value of the elementary electric charge. But when J. J. Thomson [13] proved pretty well that the cathode ray, investigated by Crookes in 1870,[14] was made up of individual charged particles which Thomson wanted to call "corpuscles," Stoney's term "electron" prevailed. One version of its derivation is that Stoney built the word from *electr(ic)* and *on*. In turn, electric is derived, through the Latin *electrum*, from the Greek word, ἤλεκτρον, for amber. It is also possible that Stoney went directly to the Greek. Half a century later, the electron has had so many practical applications that a new suffix, *tron*, has been added to the language.

The precise origin of the more recent term fission is not yet as well documented, although its derivation is easily surmised. Says Smyth:[15] "O. R. Frisch and L. Meinter guessed that the absorption of a neutron by a uranium nucleus sometimes caused that nucleus to split into approximately equal parts with the release of enormous quantities of energy, a process that soon began to be called nuclear 'fission'." The use of fission in this sense seems to date from about 1938 or 1939. In its biological sense, however, referring to the manner in which cells reproduce by splitting into two approximately

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equal parts, as does the nucleus, fission came into use about the middle of the Nineteenth Century.

Isotope is a word that was gradually creeping into the public's consciousness even before the announcement of the atomic bomb, for the tracing of metabolic processes by means of substances which can fool the body's chemistry but not the Geiger-Müller counters was vitalizing medicine and biochemistry prior to World War II. Isotopes have been called "the most useful mechanism in research since the invention of the microscope." But the tremendous installations for producing fissionable materials can also give off, either as by-products or by deliberate intent, comparatively huge amounts of radioactive and stable isotopes, and work is no longer restricted to small-scale studies of the most pressing problems. A recent story in the New York *Times* (without any attempt at a thorough survey, the author noted five news items in the *Times* relating to isotopes during December, 1947) mentioned that more than 100 stable isotopes of 29 elements are available for distribution to research laboratories in the United States. The word comes from the Greek words, *ισο*, meaning same, and *τόπος*, place; and this, as will be seen, describes an isotope accurately since all isotopes of the same element occupy the same position in the periodic table. There are uraniums [16] with mass numbers of 234, 235, and 238; they are so difficult to separate from each other that it took an immense national effort to do it in quantity. There are five forms of zinc, with atomic weights of 64, 66, 67, 68, and 70, the average weight,[17] that of zinc which is mined and used commercially, being 65.38. Similar situations exist for most of the other elements. That the existence of several varieties of the same element was the explanation for the uneven atomic numbers that so baffled the physicists was suspected by F. Soddy [18] as early as 1910. "The same algebraic sum of the positive and negative charges in the nucleus when the arithmetic sum is different gives what I call 'isotopes,'" he said, "because they occupy the same place in the periodic table." Soddy's theory was at first received with a singular lack of enthusiasm, some of the implications of his theory being in Aston's words, "extremely repulsive to orthodox physicists." But in 1912 Thomson concluded that there were two types of neon, and by 1919 F. W. Aston's mass spectrograph had established final proof.

Through necessity, the great theorists and discoverers of science have been particularly fertile inventors of words. Obviously, if the theory or the fact is a step beyond current knowledge it is also a step beyond

(*Continued on page 464*)

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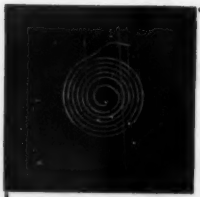
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THE SHADOWS OF SCIENCE

(*Continued from page 463*)

current vocabulary. For example, the neutron was discovered in 1932 as a by-product of research on some visitors from space that have also excited some public interest — cosmic rays. But the Oxford dictionary[19] claims that the word neutron originated in 1921, and it is conservative. The term was first used by Rutherford in his Bakerian Lecture of 1920 to describe a particle, consisting of a proton and an electron in close combination (and therefore neutral in charge), which he felt might explain some of the phenomena within the atom.

Perhaps the outstanding case of an entire technical vocabulary being synthesized by one man (and with much of it going into public use, too) is that of Freud's psychoanalysis, a term he also coined. The words "id" and "libido" in their present connotations, as well as the terms "psychosis" and "Narcissus complex," stem from his writings. Freud noted two common effects in every male neurotic he examined: a strong love for the mother, and a complementary hatred for the father. Thoroughly versed in the classics, Freud was struck by the resemblance of this situation to one of the basic myths of antiquity — the legend of Oedipus. In the Greek version, Oedipus, who solved the riddle of the Sphinx, was fated to (unknowingly) kill his father and marry his mother. Discovering what he had done, he went mad. Today, no doubt, he would visit a psychoanalyst.

Because of its association with our strongest and most hidden emotions, Freud's subject matter, approach, and terminology have had an enormous effect on painting, literature, the stage, and the motion picture. A more than usually obvious instance is *Mourning Becomes Electra*, currently a movie, but earlier a successful drama by O'Neill. Somewhat soured by what he felt was a certain lack of finesse in wedding science to art, *Time's*[20] critic reported, "By attempting to dramatize the Oedipus complex in a framework of Greek drama, O'Neill produced a travesty of Freudian thought and something like a parody of Greek tragedy." But whether they be parodies or masterpieces, the works of O'Neill, Joyce, Proust, Mann, and many others are the bellwethers of a revolution that has occurred in the public's attitude toward the problems and the ills of the mind. Witness popular reaction to the Patton face-slapping incident and the public's probable approval of a similar act had it happened during the Civil War or Spanish-American War.

One could take up the sciences in turn — astronomy, biology, chemistry, and so on — noting the once special terms that are now generally used or understood, noting how and why they entered the layman's language. Then there would be the various fields of practical application, such as transportation or electronics. Trade names, such as Technicolor, Polaroid, Plexiglas, or Kodak form a subject in themselves. More important than the word, however, is the change in thought or habit that was created by or caused its absorption into the vocabulary. It is no coincidence that, as the key terms of genetics, anthropology, or atomic physics are finding their way into common usage, laws, morals, and mores are also changing. In the words of Lord Byron, ". . . words are things, and a small drop of ink . . . produces that which makes thousands, perhaps millions, think."

(*Concluded on page 466*)

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THE SHADOWS OF SCIENCE

(Concluded from page 464)

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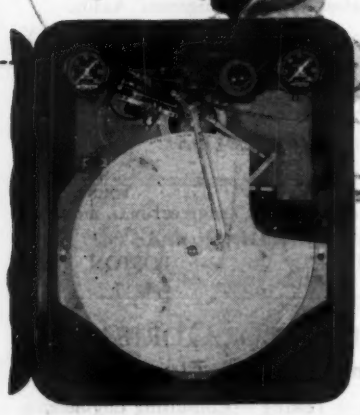

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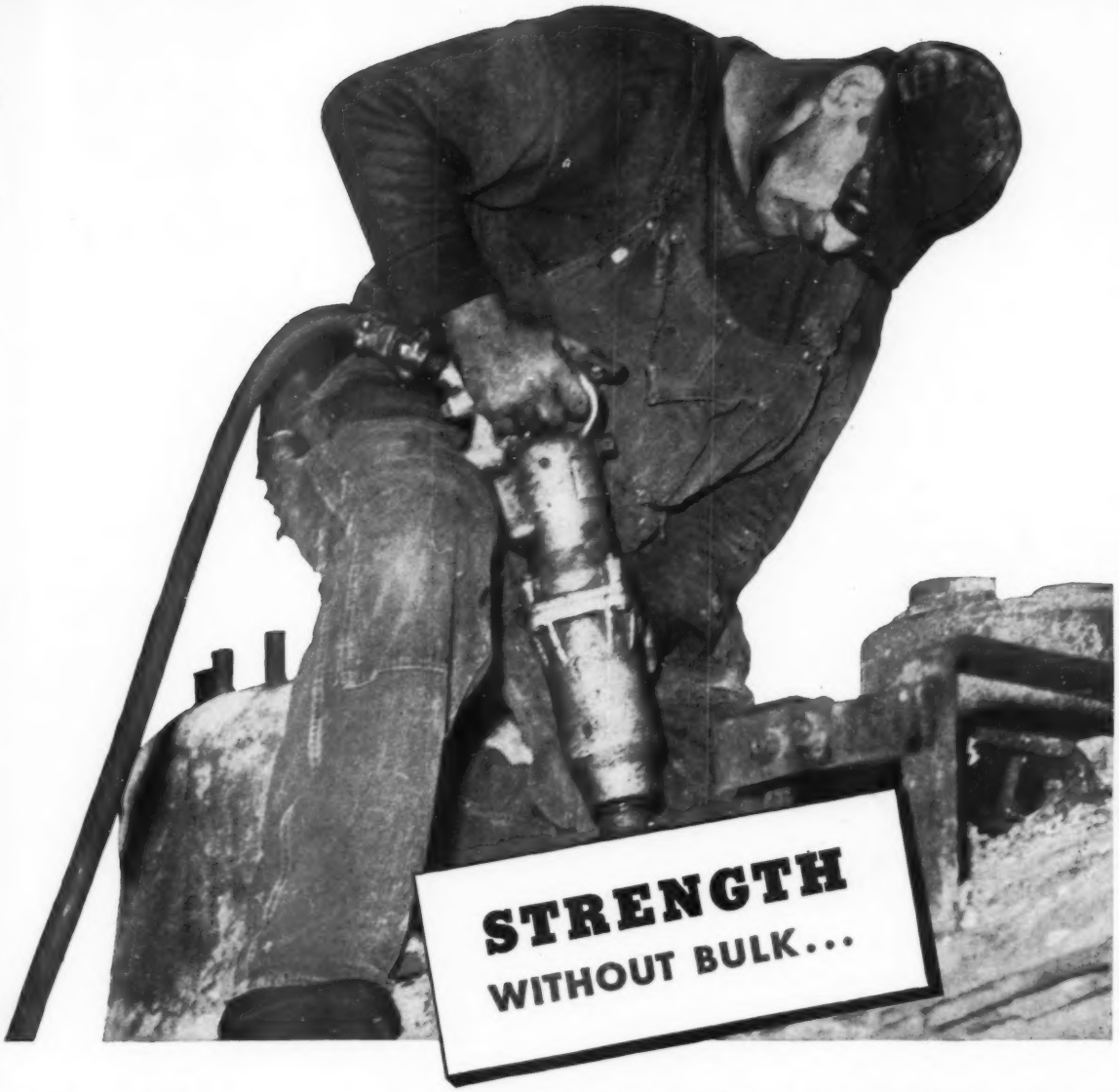

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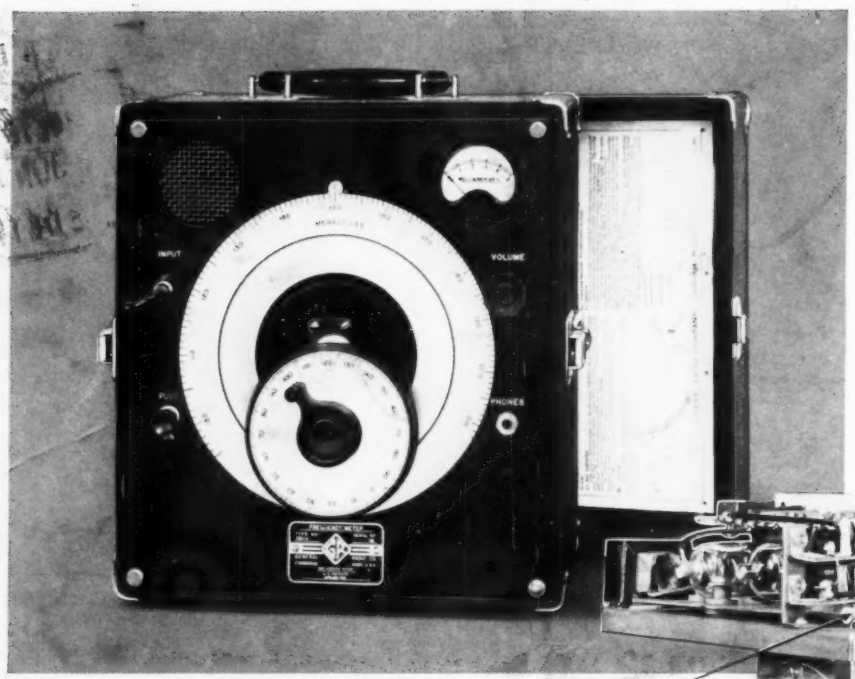

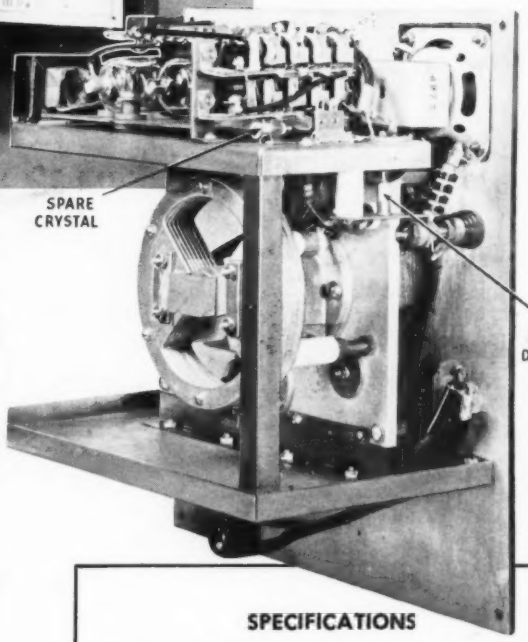

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